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A Localized Study
of
Gray Iron Foundries to
Determine Business & Technical
Commonalities Conducive
to
Reducing Abatement Costs

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16. Abstracts The thesis was that economies of scale both in purchase and in financing costs might be available to members of a group, thereby lessening the financial impact to small foundries in complying with air pollution regulations. This group buying-financing management technique was not known to have been applied to procurement and financing of air pollution abatement devices in any industry. The salient attributes of such an organization were surveyed. The various regulations in the geographical area of concern were examined to establish a tentative grouping of foundries by degree of control needed. Foundry operating procedures and cupola design factors that could affect cupola emissions were evaluated. Performance-cost tradeoff factors were studied, including a possible process change as well as a control device application. Quotations were obtained for reverberatory furnace process replacement, and for a venturi scrubber as a function of quantity. Various financing alternatives were explored, and possible group organizations and procedures were analyzed from administrative, business and legislative view points. There was no technological reason why the gas conditioning and control device portion of a total control system could not be common over a reasonable design integer for a group of foundries grouped				
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A Localized Study of Gray Iron Foundries to
Determine Business & Technical Commonalities
Conducive to Reducing Abatement Costs

Prepared for the
Office of Air Programs
Environmental Protection Agency
Under Contract 68-04-0043

J.A. Commins & Associates, Inc.
Fort Washington, Pennsylvania 19034

January 1972

SUMMARY

The extent of technical and business commonalities in gray iron foundries which would be conducive to reducing air pollution abatement costs was examined ^{WAS} on the thesis ^A that economies of scale both in purchase and in financing costs might be available to members of ~~the~~ group, thereby lessening the financial impact to small foundries in complying with air pollution regulations. This group buying-financing management technique had, to our knowledge, ^{WAS NOT APPLIED TO GROUPS} never been applied to procurement and financing of air pollution abatement devices in any industry.

This study involved about five man-months of investigative effort over a six-month period. It did not attempt to develop an additional statistical base of foundry data due to time and budget limitations and the fact that this industry had already been extensively studied on a statistical basis.

The purpose of the part of the study concerned with possible organizations for conducting the group action was to provide a survey of the salient attributes of such ^{WERE SURVEYED} organization rather than act as a definitive text.

The first step was to examine ^{WERE SURVEYED} the various regulations in the geographical area of concern ^{WERE SURVEYED} to establish a tentative grouping of foundries by degree of control needed. Next, foundry operating procedures and cupola design factors that could affect cupola emissions were evaluated. Armed with the emissions allowed, and those predicted from cupola design and foundry operating variables, performance-cost tradeoff factors were studied, including a possible process change as well as a control device application.

170
Quotations were obtained for reverberatory furnace process replacement, and for a venturi scrubber as a function of quantity. Various financing alternatives were explored, and possible group organizations and procedures were analyzed from administrative, business and legislative view points.

The study found that there was no technological reason why the gas conditioning and control device portion of a total control system could not be common over a reasonable design integer for a group of foundries grouped primarily on melt rate and the volume of blast and infiltrated air in their operations. Interconnecting ductwork, supports, and foundations etc., are unique and not susceptible to technological grouping.

Further, the study found that net savings could be made from group purchase of reverberatory furnaces and wet scrubbers. Sizeable savings would be available via group financing, although it was impossible to establish on a hypothetical basis that financial sources would positively conduct business with a group, even if the risk background of members comprising the group was similar and good.

The biggest obstacle to utilization of group action despite the predicted benefits are the natural reluctance of small, largely individually-owned companies to "join forces". This is attributed to the lack of precedent, the feeling that somehow the particular company might escape compliance, or the feeling that they could get a better bargain on their own. This reluctance would best be overcome by an actual successful demonstration of the technique with a trial group of foundries where formal commitments by individual companies to group actions, risks, and benefits were gradual, and for which administrative expenses on the original trial run were covered outside the group.

FOREWORD

Attainment of emission compliance through control devices or process changes is a unique management problem for the small gray iron foundry because of the immediacy of the need, the complexity of the factors bearing on the management decision, and the financial impact of the acquisition or change. This study investigated the extent to which a management technique involving group action could ameliorate the problem in small gray iron foundries. If promising, the findings might also be applied to other industries with appropriate adjustments to particular business and technical factors.

In the course of this work frequent contact was made with regulatory agencies at several levels, the financial community, control device and furnace manufacturers, foundry operators, and trade associations. For the most part, we received good cooperation from all of these bodies. However, we especially acknowledge the cooperation of Mr. John S. Cole of the Pennsylvania Industrial Development Authority, Department of Commerce; Larry Hill of Polycon Corporation; Rao Kona of the Pennsylvania Bureau of Air Quality and Noise Control, Department of Environmental Resources; Lou Calzi of John P. Clark Company; William Miller, Air Management Services, Philadelphia Department of Public Health; and Paul Alman, Penton Publishing Company.

About the time most of this work was completed and the final report writing completed, Pennsylvania submitted their final implementation plan to EPA. This plan made important changes to the earlier proposed

regulations for foundries cited in the report, especially those melting five tons or less per hour. Because this change was made known publicly on January 27, 1972, it was not possible to incorporate this important change in the discussion and examples given in the report; however, a graph indicating the new particulate requirements appears in the Appendix as Figure 1-2a.

The views and findings of this report are those of J.A. Commins and Associates, Inc., and do not necessarily reflect the thoughts of, nor do they have the endorsement of the Environmental Protection Agency.

LIST OF FIGURES

Figure	Page
1-1	Cumulative Distribution of Melt Rate Capacities..... 1-4
1-2a	Pennsylvania Cupola Allowable Emissions..... 8-17
1-3	Various Regulations for Particulates in Pennsylvania..... 1-8
1-4	Allowable Emissions Per Regulation IV..... 1-10
1-5	Pennsylvania Proposed Particulate Regulations..... 1-14
1-6	Emissions Allowable Under Various Regulations..... 1-16
2-1	Efficiency - Particle Size Relationship for a Wet Scrubber. 2-9
2-2	Wet Scrubber Overall Efficiency - Pressure Drop Relation- ship for Cupola Operations..... 2-10
2-3	Relative Change in Annual Costs with Pressure Drop in Wet Scrubbers..... 2-12
2-4	Wet Scrubber Size Index vs. Capacity..... 2-15
2-5	Fabric Filter Size Index vs. Capacity..... 2-16
2-6	Initial Cost of Cupola System with High Energy Wet Scrubber..... 2-17
2-7	Initial Cost of Cupola System with Fabric Filter..... 2-18
2-8	Annual Cost of Cupola Control System with High Energy Wet Scrubber..... 2-19
2-9	Annual Cost of Cupola Control System for Low Melt Rates with Fabric Filter..... 2-20
2-10a	Effect of Draft Through Charge Door on Scrubber Initial Costs..... 8-18
2-11a	Effect of Draft Through Charge Door on Fabric Filter Initial Costs..... 8-19
2-12a	Effect of Draft Through Charge Door on Wet Scrubber Annual Costs..... 8-20

LIST OF FIGURES (Continued)

Figure		Page
2-13a	Effect of Draft Through Charge Door on Fabric Filter Annual Costs.....	8-21
2-14	Fabric Filter Annual Cost Distribution.....	2-23
2-15	High-Energy Wet Scrubber Annual Cost Distribution.....	2-24
3-1	Present Value of Net Outflows due to Various Financing Alternatives.....	3-14
3-2	Excess Cost of Financing Over Group Bond Issue.....	3-15
3-3	Effective Cost of Pollution Control Equipment From Various Financing and Tax Alternatives.....	3-20
3-4	Annual funds Surplus/Deficit for Various Financing and Tax Alternatives.....	3-21
3-5	Effect of Initial Cost on the Relative Rating of Financing Alternatives.....	3-24
4-1a	Cupola Blast Volume - Melt Rate Relationship.....	8-22
4-2a	Cupola Blast Volume - Melt Rate Relationship.....	8-23
4-3a	Blast Volume - Melt Rate Relationship at Low Melt Rates....	8-24
4-4	Wet Scrubber Initial Cost vs. Output Loading.....	4-13
4-5	Scrubber Operating Costs vs. Output Loading.....	4-14
4-6	Wet Scrubber - Cupola Schematic.....	4-17
4-7	Common Group Screening Process.....	4-19

LIST OF TABLES

Table	Page
1-A Source Factor Table.....	1-15
2-A Components of Pollution Control Costs.....	2-2
3-A Financial Assistance and Tax Incentives for Industry.....	3-9
4-A Compliance Order Deadlines.....	4-2
4-B A Typical Grouping for Small Foundries.....	4-5
4-Ca Particle Size Distribution - Cupola Emission.....	8-15
4-D Economic Comparison - Gray Iron Melting, 2 Tons/Hr.....	4-22
4-E Reverberatory Furnace Savings as Function of Quantity.....	4-23
4-F Percent Savings over Unit Buy.....	4-24
5-A Possible Organizational Forms for Group Action.....	5-2
5-Ba Partial Listing of Industry Associations Related to Foundries.....	8-16
5-C Preliminary Classification by Theoretical Analysis and Stack Sampling.....	5-12
5-D Governmental and Quasi-Governmental Organizations.....	5-21

CONTENTS

	Page
Section 1. Introduction.....	1-1
1.1 The Purpose of the Study.....	1-1
1.2 The Industry Studied.....	1-2
1.3 Study Methods Used.....	1-5
1.4 Organization of the Report.....	1-7
1.5 The Applicable Laws & Regulations.....	1-9
1.5.1 Geographical Variables.....	1-9
1.5.2 Trends.....	1-12
1.5.3 Impact of Federal Requirements.....	1-13
1.6 The Compliance Alternatives.....	1-17
1.6.1 Control Equipment.....	1-17
1.6.2 Process Changes.....	1-20
1.6.3 Limitations on Production Volume.....	1-22
Section 2. Variability of Costs with Process and Equipment Parameters.....	2-1
2.1 Description of Cost Components.....	2-1
2.1.1 Initial Costs.....	2-3
2.1.2 Annual Costs.....	2-4
2.2 Process Variables.....	2-4
2.2.1 Particulate Loading in Gas.....	2-5
2.2.2 Volume Flow Rate of Gas.....	2-5
2.2.3 Exit Gas Temperature.....	2-6
2.2.4 Chemical Composition of Gas.....	2-6

CONTENTS (Continued)

	Page
2.3 Variability of Costs with System Variables.....	2-6
2.3.1 Collection Efficiency of the System, Effluent Rage.....	2-7
2.3.2 Gas Flow Rate.....	2-13
2.3.3 The Charge Door.....	2-22
2.4 Control Cost Components.....	2-22
2.5 Comments on Accuracy of Cost Data.....	2-22
 Section 3. Variability of Costs with Financing Alternatives.....	 3-1
3.1 Methods Used in Analyzing Financing Costs.....	3-2
3.1.1 Present Value Analysis.....	3-4
3.2 Bank Financing.....	3-6
3.2.1 Pollution Control Equipment Loan.....	3-7
3.3 Financing Through Cash Flow.....	3-8
3.4 Governmental Aid to Financing.....	3-8
3.5 Special Tax Considerations.....	3-13
3.5.1 State and Local Tax Preferences.....	3-16
3.5.2 Accelerated Writeoffs.....	3-16
3.6 Effective Cost of Equipment.....	3-19
3.7 Cash Deficit Considerations.....	3-21
3.8 Effect of Initial Cost on the Financing Alternatives.....	3-23
 Section 4. Effect of Group Action.....	 4-1
4.1 Identification of Appropriate Group(s).....	4-1

CONTENTS (Continued)

	Page
4.2 Effect on Equipment Cost.....	4-20
4.2.1 Reverberatory Furnace.....	4-21
4.2.2 Wet Scrubber.....	4-24
4.3 Effect on Financing Costs.....	4-28
4.4 Group Relations with Regulatory Bodies.....	4-30
Section 5. Vehicles for Group Action.....	5-1
5.1 Existing Industry Associations.....	5-3
5.2 Special Purpose Organizations.....	5-5
5.2.1 For Single Specific Transaction.....	5-6
5.2.2 Of Extended Duration.....	5-14
5.3 Governmental Corporation.....	5-19
Section 6. Special Problems.....	6-1
6.1 Permissibility of Group Action.....	6-1
6.2 Enabling Legislation.....	6-9
6.2.1 Necessity.....	6-10
6.2.2 Achievability.....	6-11
6.3 Persuasion to Group Action.....	6-12
6.4 Procedures of Group Action.....	6-15
6.5 Distribution of Risks & Benefits.....	6-18
Section 7. Conclusions and Recommendations.....	7-1

CONTENTS (Continued)

	Page
Appendix.....	8-1
Exhibit 1 Budgetary Request for Control Device.....	8-2
Exhibit 2 Stack Sampling Price Request.....	8-5
Exhibit 3 Request for Technical & Cost Data.....	8-11
Exhibit 4 Discussion Guide for Foundry Visits.....	8-12
References.....	9-1

1. Introduction

1.1 The Purpose of the Study

The study sought to evaluate a group specifying-buying-financing management technique for potential use in gray iron foundries in obtaining appropriate air pollution control.

Denied, because of size and economic posture the variety of personnel expertise needed to effectively implement control devices, and faced with a non-productive investment requirement running to sizeable fractions of current fixed assets, small gray iron foundries are seriously adversely affected by compliance with strict air pollution requirements. This fact is strikingly emphasized by recent government reports. The Secretary of Health, Education and Welfare's Report³⁹ to Congress entitled, "National Emission Standards Study" states on page 90, "...This industry (Gray Iron Foundry) is another example of one where many operations are small and cost of effective controls would be a problem." And, in Appendix D of the same report, "...if the Gray Iron Foundry is typical of small business with severe pollution problems, it is clear that the compliance with emission standards will be an economic strain. Some may be forced out of operation..." The Administrator of the Environmental Protection Agency in his 1971 report³ to Congress, in speaking of Gray Iron Foundries on page 4-66 states that, "Many firms, faced with reduced profit margins and an inability to raise capital for pollution control will be forced to merge or go out of business. Some remaining firms will continue to operate at reduced profit rates. In effect, pollution control will accelerate the trend toward fewer and larger foundries. It is apparent that the gray iron foundry industry

will be among those industries most severely affected by air pollution control."

Group methods of specifying, buying and financing were thought worthy of study because they held some promise of reducing the financial outlay, and of spreading the reduced amounts over several times the period of conventional bank financing, thereby softening this impact on the small foundries.

Area of savings in purchasing should arise from reduced costs to the vendor of raw materials, purchased parts, better proration of fixed overhead, labor efficiencies, and reduced sales and engineering expenses. Financial advantages of lower interest and longer term financing are expected to derive from a greater loan base, which could attract long term low interest public money, while keeping the underwriting expense to obtained capital ratio low.

1.2 The Industry Studied

The gray iron foundry industry melts iron, including a considerable amount of scrap, in furnaces, and fashions this melted material via a molding process into a wide range of gray, malleable and ductile iron castings, ranging from small castings to those weighing hundreds of pounds.

The industry is presently in the top 5% of manufacturing industries in employment, and in the top 12% in shipments.⁴⁰ Foundries are located in or near almost all cities of over 60,000 with 1,055 foundries reported in 1967. (SIC 3321 only, BDSA-NAPCA Gray Iron Foundry Air Pollution Survey identified 1,376 foundries operating in 1967 and Foundry Magazine reported 1,653 for the same period. These differences in plant statistics are probably due to the ratio of gray iron produced per plant.)

The products of these foundries are iron casting, and these enter into an extremely wide variety of manufactured products. For example, such

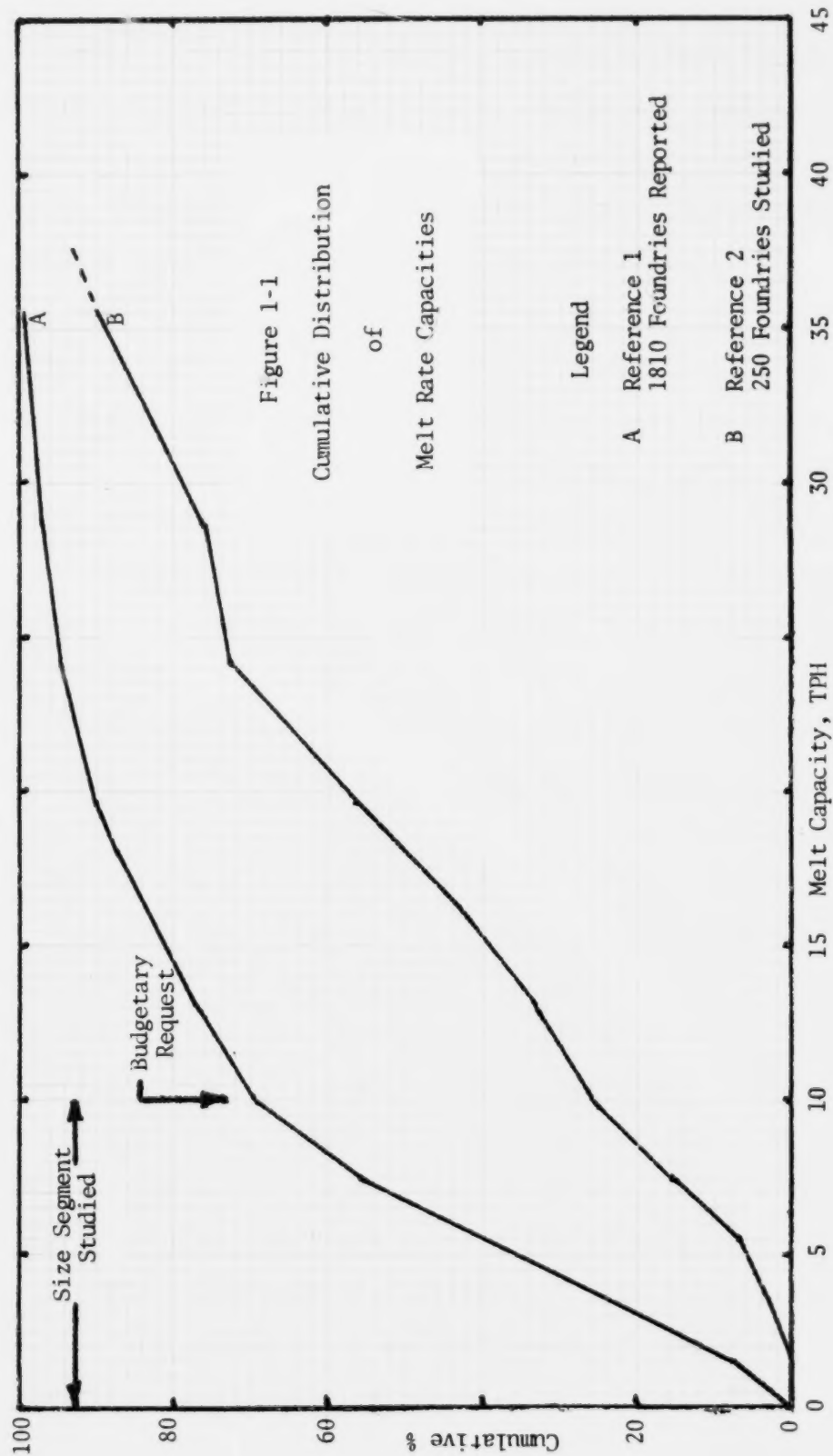
castings constitute many of the metallic constituent elements of automobiles, of appliances, and of all sorts of production machinery. Hydraulic valves are often made of such castings, as are other elements of water and sewage systems, such as pipes, manhole covers, filter plates, etc.

Where particular forms of such castings are replicated in large quantities--as in the case of those used in automobiles--the foundries which manufacture them are generally owned by the same concern which makes use of its castings output. These are known as "captive" foundries, in recognition of their status as owned by their principal customer.

Where smaller quantities of particular castings are required in greater variety, these are commonly manufactured by independently owned foundries, known as "jobbing" foundries. Jobbing foundries are usually family-owned or held as a small closed corporation without outside equity capital. Thus the situation where the owners and managers of the business are the same.

Captive foundries are usually larger than jobbing foundries, the former typically having work forces of more than 50, while the latter typically have 50 or less. They may also be a division of a large widely held corporation where management and ownership are separate. Captive foundries are generally capital intensive, whereas jobbing foundries are more labor intensive.

There has been, for some time, a trend toward fewer small, jobbing foundries. For example, during the period of 1959-1967, there were 251 closings of foundries employing less than 50 people, representing a 30% decline in the number of plants in this category, while larger foundries increased during the same period, and the total foundry output did not go down. There remain even now about 500 "small" foundries, i.e., those employing 50 or fewer people, and it was the smaller foundry that was the subject of this study.



The study was concerned with foundries in Philadelphia, Allegheny and Erie Counties, with the following melt rates in tons per hour:

<u>Philadelphia County</u>	<u>Erie County</u>	<u>Allegheny County</u>
(5 Foundries)	(14 Foundries)	(7 Foundries)
1	3 12	57
6	3 5	14
3.5	5 5	5
1.5	9 4	7
4.5	3 8.5	6
	3.8 10	3
	3 8	6

We classified small foundries as those with melt capacities of ten tons per hour or less, and concentrated the study in this class. Figure 1-1 shows the distributions of melt rates in the United States per Reference 1, and those studied in Reference 2, which provided much of the statistical information used in this study.

1.3 Study Methods Used

This study is considerably different in purpose from other studies conducted in this industry. The three other principal studies^{1,2,3} were primarily diagnostic in character in that they sought to "identify the costs and to assess the economic impact of controlling air pollution..." or they attempted "to define the air pollution problems of the iron foundry industry, and to set priorities for research and development work..." or they examined the micro-economic impact of air pollution control. These studies, being principally diagnostic in character, developed much clinical information by way of

questionnaires, extensive plant visits and reliance on aggregated industry data. These data in essence depict the smaller foundry as being in a precarious condition because of its low reported profit levels, generally low business activity, and the relatively high cost of control equipment.

The purpose of this study is therapeutic rather than diagnostic. As such, it has relied to a large extent on the wealth of statistical technical data already in existence from studies such as the aforementioned. In addition, emission data at the Pennsylvania Bureau of Air Quality & Noise Control was analyzed, detailed discussions were conducted with eight device manufacturers, and budgetary proposals were solicited for reverberatory furnaces and control devices from about forty companies.

No claim is made that this study developed new statistically valid information. It was not the intent to elicit further information from a large statistical foundry base since the industry has been subjected to intensive studies, so that the incremental improvement in data, even if study time and funds permitted, would have been decidedly cost inefficient.

In order to obtain a first hand knowledge of management approaches to pollution control problems, however, and to develop a feel of the small foundry operations, seven plant visits were made (see Exhibit 4 for discussion guide). Two of the seven visits were to small foundries which had changed from cupola melting to reverberatory furnaces, and the other five visits were to plants that all used cupolas with hand loading.

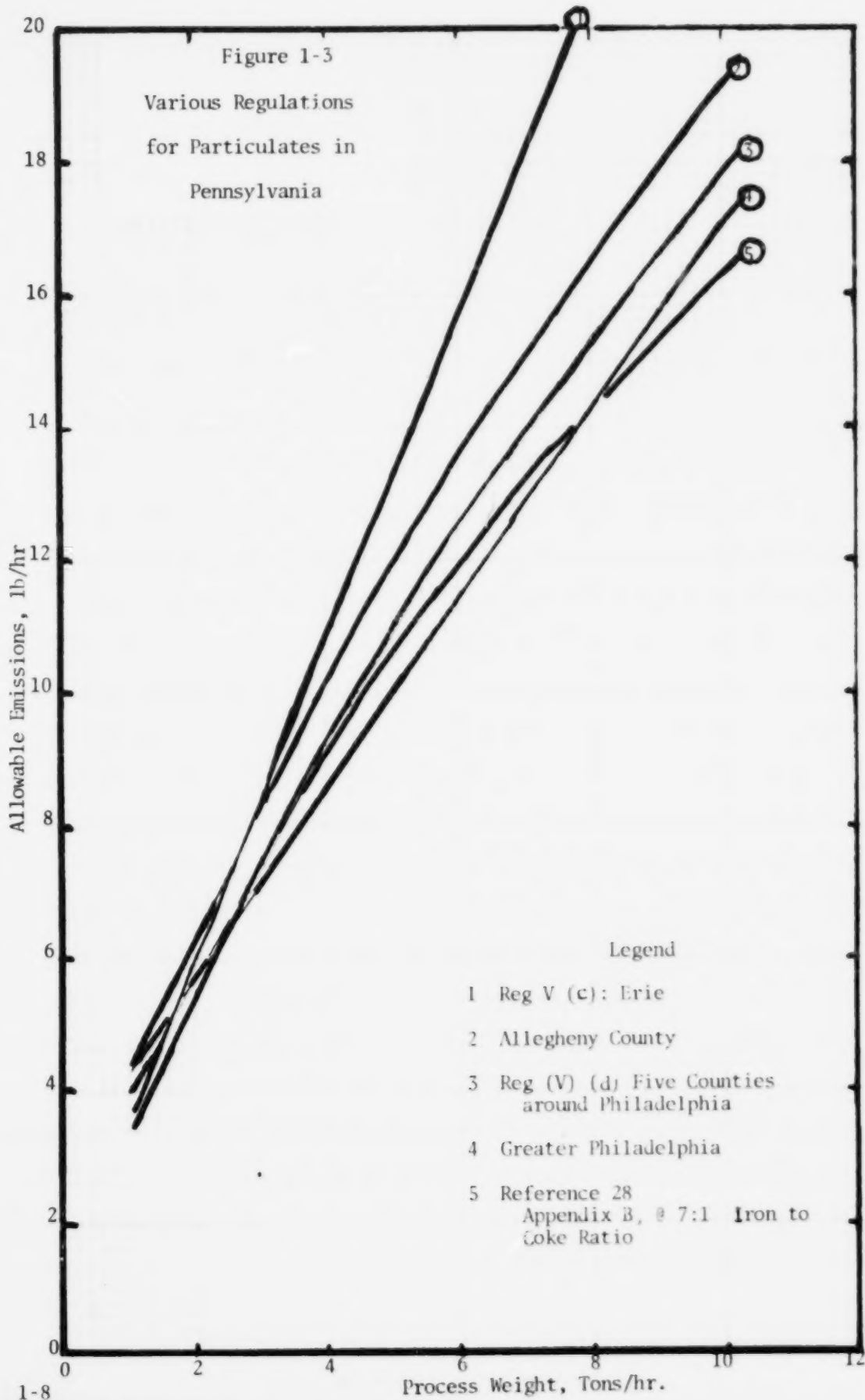
An attempt was made to set up a meeting at the Industrial Gas Cleaning Institute, since group membership in IGCI represents approximately 80% of sales in the industrial gas cleaning market. The IGCI stance was that their members

had provided so much free information to such studies in the past that they now discourage such inquiries unless accompanied by satisfactory remuneration. Recourse then was to individual companies, several of whom are members of the IGCI.

Two national associations in the foundry industry, The American Foundrymen's Society, and the Gray and Ductile Iron Founders Society, were also visited.

1.4 Organization of the Report

The report consists of seven sections including the introduction. The first three sections discuss factors such as regulations, compliance alternatives, variability of costs with required system performance, and variability of costs with financing alternatives. These are factors which determine the group make-up, namely its geography, and the number of possible members. The broader the technical tolerance, for example, on gas flow per unit time (whether $\pm 10\%$ or $\pm 20\%$), the more possible members for the group, but on a 20% size spread, the member with the smallest gas volume may not find significant benefits by group buying because the equipment must also handle the needs of the member with the greatest gas volume. Even if quantity buying of a larger size unit would save money on that unit, the savings may not be attractive to someone with 20% lower gas volume since he might be able to obtain a better break by buying one unit 20% smaller. (These percentages are used here to make the point, but may not represent a real situation.) It would likewise be practically impossible to find ten foundries within a reasonable geographic area with exactly 13,480 scfm (noted as an example in Section 4.) Therefore the first three sections deal with factors that influence the technical spread that would define an economically viable group.



Section 4 outlines how such a group could be identified, and gives examples of possible group savings from economies of scale in acquisition and financing of one process alternative, and one type of control device. It is much easier to define a group from technical and monetary viewpoints than it is to get such a number of companies to desire to form a group, organize themselves, and provide proper administration of the group functions. Section 5 analyzes several vehicles for group action and briefly notes problems to be encountered, while Section 6 is entirely devoted to non-technological problems that must be overcome.

Section 7 contains Conclusions and Recommendations.

We have endeavored to keep graphs and tables which interact extensively with the text close to the text that bears on them. Figures and Tables are noted 2-3, 4-A, etc., where this notation means Section 2, Figure 3 or Section 4, Table A, etc. If an 'a' is found, such as 4-3a, it means that Figure 3 of Section 4 will be found in the Appendix, since the Figure or Table need not be frequently referred to when reading the text.

1.5 The Applicable Laws and Regulations

1.5.1 Geographical Variables

This study was concerned with three areas of Pennsylvania, namely the counties of Philadelphia, Erie and Allegheny.

As of this writing, there still exist in Pennsylvania many different regulations governing particulates. Figure 1-3 indicates four of these areas. The top curve shows allowable emissions per Regulation V¹² in air basin category (C), which is Erie. Curve 2 pertains to Allegheny County¹⁴ (Pittsburgh);



Figure 1-4

curve 3 to the five counties surrounding Philadelphia, and curve 4, the Greater Philadelphia area¹³. Curve 5 is based on Appendix B of Reference 28. In addition to these regulations which are based on process weight, there is another regulation, Regulation IV¹¹, which is supposed to be applied statewide in the event it is more strict than Regulation V or the codes governing Philadelphia and Allegheny counties. In practice, we find that only the county codes are applied in Philadelphia and Allegheny Counties, while in the rest of the state, Regulation IV is customarily applied, since it is usually more strict than the air basin code.

Regulation IV utilizes effective stack height and distance to property lines so that the regulation curve cannot be shown on the coordinates of Figure 1-3 unless several simplifying assumptions are made. In the case of Regulation IV, the height of the plant stack and its proximity to its neighbors are the determining factors in the regulations that pertain rather than the plant's geographical location in Pennsylvania. This is indicated in Figure 1-4.

Effective stack height for all plants with the temperature of flue gas greater than 650 F, which is true for cupolas, is given by the equation:

$$H_e = \frac{H + (1.5V_s d + 4.09 \times 10^{-5} Q_h)}{u}$$

where,

H_e = effective stack height, meters

H = stack height, meters

V_s = stack gas ejection velocity, meters per second

u = wind speed, meters per second (Assume 3.8 meters per second unless other acceptable meteorological data are available for the stack locality.)

d = internal diameter of stack top, meters

Q_h = heat emission rate of stack gas relative to ambient atmosphere, calories per second

$$Q_h = Q_m C_{ps} \Delta T$$

where,

Q_m = mass emission rate of stack gas, grams per second

C_{ps} specific heat of stack gas at constant pressure, calories per gram per $^{\circ}K$

ΔT = $T_s - T$

T_s = temperature of stack gas at stack top, $^{\circ}K$

T = temperature of ambient atmosphere, $^{\circ}K$ (Assume ambient atmospheric temperature is $283^{\circ}K$ unless other acceptable meteorological data are available for the stack locality.)

1.5.2 Trends

Commencing about Spring of 1971, regional meetings convened by the Pennsylvania Bureau of Air Quality and Noise Control were held with several industry groups including the foundry industry. At these meetings, the companies were told they were out of compliance with Regulation IV based on data from the Emission Inventories, visits by local state engineers, and a calculation of uncontrolled emissions utilizing emission factors of Reference 17 compared with allowable emissions calculated via effective stack height and property line requirements of Regulation IV. In many instances attending plant representatives signed a Stipulation and Agreement document whereby the Commonwealth agreed not to institute legal or administrative procedures against the company, providing the company embarks on a prescribed schedule to meet the standards of Regulation IV.

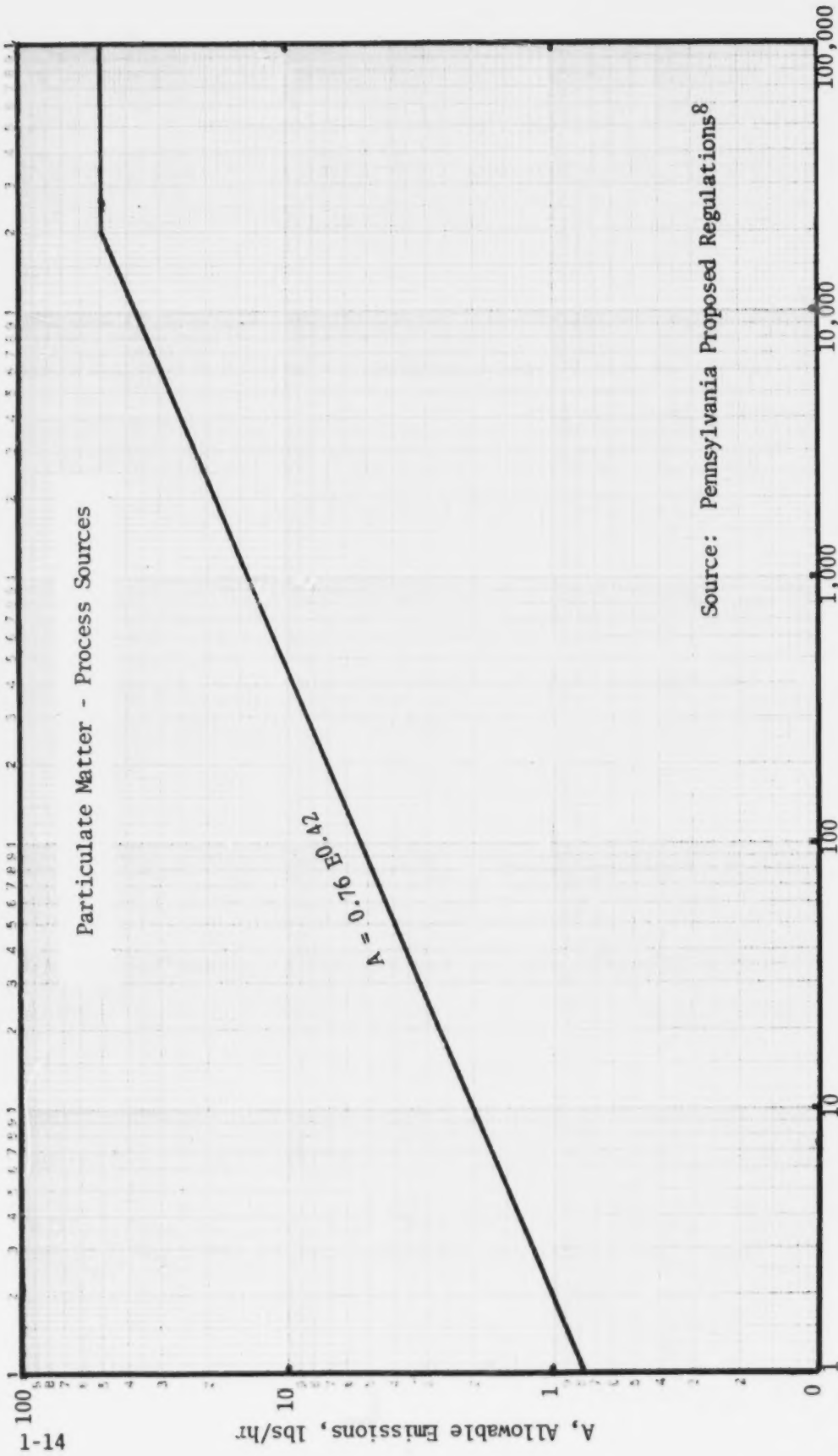
The trend in Pennsylvania has therefore been to operate on an industry-wide basis in enforcing controls, using Regulation IV. As noted, this regulation is based on effective stack height and distance to the property line, but as can be seen from reference to Figure 1-4, taken from Regulation IV, property lines do not become a factor, even for short effective stack heights unless the nearest distance to the property line is over 800 feet. Therefore, the only important variable for most foundries under Regulation IV would be stack height above grade.

Since this information is elicited in the Emission Inventory forms, an allowable emission based on Regulation IV can be predicted for each foundry in Pennsylvania.

1.5.3 Impact of Federal Requirements

The impact of federal ambient standards will be to change the level of allowable emissions, and to eliminate the variations shown in Figure 1-3. The Proposed Pennsylvania regulations for particulates are indicated in Figure 1-5. By "proposed" is meant the regulations submitted to public hearings in connection with the submission of the state's implementation plan required by the Clean Air Act of 1970. In using Figure 1-5, the Emission Index is obtained by multiplying the Source Factor F as shown in Table 1-A by the production rate of the material in tons per hour. The reader must not confuse this source factor with the emission factor of Reference 17. The latter was based on empirical data on actual emissions per ton of product, while the former is an assigned number fitting into Pennsylvania's overall emission program.

Figure 1-6 compares allowable emissions under three different regulations: the present Regulation IV (assuming all plants have an effective stack height



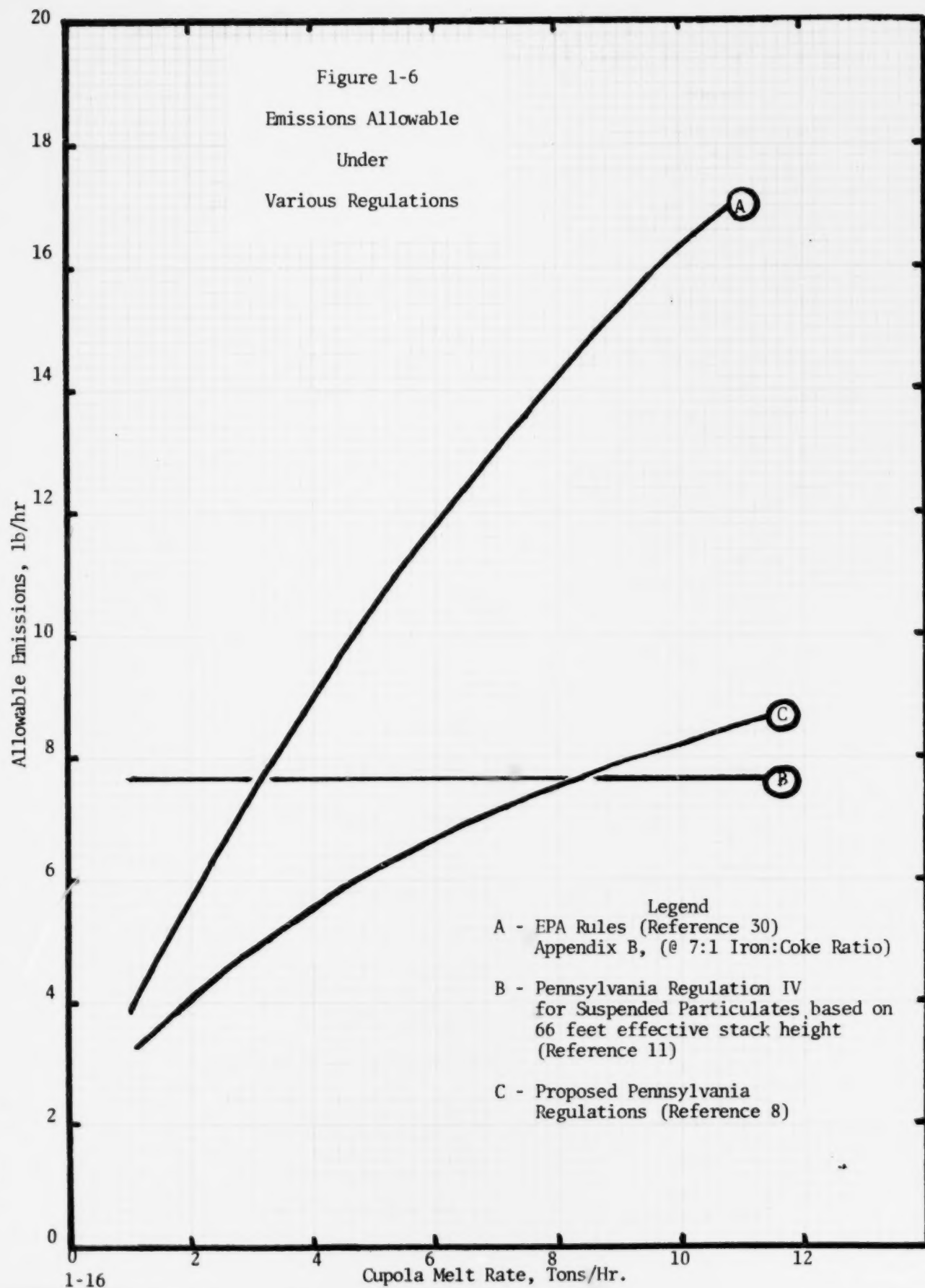
E, Emission Index, lbs/hr

Figure 1-5

Table 1-A (Source: Reference 8)

Unless otherwise specified in this table, the entire process, from receipt of raw materials to load-out of product, shall constitute a source.

Source	Source Factor, F
1. Carbon black mfg.	500 lbs./ton of product
2. Charcoal mfg.	400 lbs./ton of product
3. Crushers or grinders or screens	20 lbs./ton of feed
4. Paint mfg.	0.05 lbs./ton of pigment handled
5. Phosphoric acid mfg.	6 lbs./ton of phosphorous burned
6. Phthalic anhydride mfg.	600 lbs./ton of product
7. Plastics mfg.	1 lb./ton of product
8. Printing ink mfg.	800 lbs./ton of product
9. Detergent drying	30 lbs./ton of product
10. Alfalfa dehydration	30 lbs./ton of product
11. Grain elevators:	
Loading or unloading	90 lbs./ton of product
12. Grain screening and cleaning	300 lbs./ton of product
13. Grain drying	200 lbs./ton of product
14. Meat smoking	0.01 lbs./ton of meat
15. Ammonium nitrate mfg.:	
Granulator	0.1 lbs./ton of product
16. Coke mfg.	4 lbs./ton of coal
17. Ferroalloy production furnace	0.3 lbs./ton of product
18. Primary iron and steel making:	
Iron production	100 lbs./ton of product
Sintering: windbox	20 lbs./ton of dry solids feed
Steel production	50 lbs./ton of product
Scarfig	20 lbs./ton of product
19. Primary lead production:	
Roasters	0.004 lbs./ton of ore feed
Sintering	0.2 lbs./ton of sinter
Lead reduction	0.5 lbs./ton of product
20. Primary zinc production:	
Roasters	3 lbs./ton of ore feed
Sintering	2 lbs./ton of product
Zinc reduction	10 lbs./ton of product
21. Secondary aluminum production:	
Sweating	30 lbs./ton of aluminum feed
Melting and refining	4 lbs./ton of aluminum feed
22. Brass and bronze production:	
Melting and refining	1 lb./ton of product
23. Iron foundry	
Melting	30 lbs./ton of product
24. Secondary lead smelting	0.5 lbs./ton of product
25. Secondary magnesium smelting	0.2 lbs./ton of product
26. Secondary steel making:	
Melting and refining	30 lbs./ton of product
27. Secondary zinc smelting:	
Sweating	0.01 lbs./ton of product
Refining	0.3 lbs./ton of product
28. Asphaltic concrete production	3 lbs./ton of aggregate feed
29. Asphalt oxidation	0.6 lbs./ton of product
30. Asphalt roofing mfg.	
Felt saturation	0.6 lbs./ton of asphalt used
31. Portland cement mfg.:	
Clinker production	150 lbs./ton of dry solids feed
Clinker cooling	50 lbs./ton of product
32. Coal drying	2 lbs./ton of product
33. Coal dry-cleaning	2 lbs./ton of product
34. Lime calcining	200 lbs./ton of product
35. Petroleum refining:	
Catalytic cracking	60 lbs./1000 bbl. of feed



of 66 feet and property line distance is of no consequence), the proposed Pennsylvania legislation and the federal ambient standards. It is evident from Graph C that the proposed Pennsylvania requirements are somewhat tougher than any of the present mix of control regulations in Pennsylvania, especially for the small plant. (This has since been changed, see Figure 1-2a)

The effect of such regulatory changes on the commonalities under this study is that within Pennsylvania it practically eliminates any necessity for concern over plant location, thus establishing a common regulation base, and permitting study effort to be directed toward plant commonalities.

1.6 The Compliance Alternatives

1.6.1 Control Equipment

It was not the intention of the study to develop a detailed account of the technical and cost characteristics of the various control equipments which has been the subject of many texts for general applications, and at least two writings specifically applied to foundries. For this reason, this section is limited to a brief listing of control equipments most likely to be considered for the small foundry.

By control equipment is meant gas conditioning equipment such as quenching sections as well as the gas cleaning device and ancillary equipment. Ducting to the cupola, and support structures, being unique to every installation, are not included, as described more fully in Section 4.

Theoretically, a foundry could utilize a variety of basic collectors, each with their own subgrouping. A foundry could theoretically choose from electrostatic precipitators, fabric filters, wet collectors, and dry centrifugals. This theoretical gamut can be quickly reduced since dry centrifugal collectors, no matter how efficiently designed, will not meet

Pennsylvania regulations.

Electrostatic precipitators have had very limited use in U.S. foundries. Several operating characteristics have probably inhibited their acceptance. The operation of precipitators is dependent on resistivity of the particles, and the resistance of the particles is in part dependent on moisture and temperature of the gas which would have to be closely controlled to maintain the appropriate particle resistivity. Another consideration is the fixed cost, which for power equipment for gas volumes less than 45,000 cfm, usually results in disproportionate acquisition costs for small foundries as compared to other devices. For practical purposes in small foundries, the choice is therefore limited to wet collectors and fabric filters.

Any type of wet collector employs one or several techniques to do one or more of the following:

- Increase effective particle size;
- Increase particle velocity;
- Break up the gas flow pattern;
- Increase the water-air surface contact area.

Among wet collectors there are a number of subgroupings including wet caps, centrifugal sprays, venturis, and flooded bed units. Wet caps alone will not meet Pennsylvania standards, although they are sometimes used as a primary collector and part of the gas conditioning portion of a satisfactory wet system.

Centrifugals, although more efficient than wet caps, also would probably not meet Pennsylvania standards. The centrifugal spray combines

high kinetic energy water droplets with the gas effluent. This is the opposite of a venturi scrubber which develops high static pressure across the collector to accelerate the gas, but in common with the venturi scrubber, uses high input power to obtain this velocity differential. The flooded bed units utilize direct contact of dirty gases with a turbulent water source.

Wet collectors like these can handle hot, moist gases and sticky dust with high efficiencies down to 0.4 microns, but all have common problems-- they require high power consumption, are susceptible to clogging and corrosion, and produce a slurry that sometimes causes disposal problems. Power costs represent 40% or more of the operational expenses, and can be accurately predicted. These costs can vary by a large amount from plant to plant, based on rate schedules that depend on a plant's electrical consumption before and after installation of the wet collector.

Fabric filters have high and flat efficiencies over practically all particle sizes to be encountered. They do require a higher degree of gas conditioning in that the temperature and moisture must be controlled, but they operate with a low pressure drop compared to venturi scrubbers, and are not subject to corrosion or sludge disposal problems. They can also handle large gas volumes and can, if properly designed, accommodate fairly large volume fluctuations. On the other hand, acquisition cost is higher than for a comparable wet collector. Periodic bag replacement costs are the biggest operational factor, representing about 54% of the yearly maintenance expenses.¹⁰ Dry material handling can also pose something of a disposal problem.

1.6.2 Process Changes

Rather than utilizing the cupola as the melting furnace, it is possible to change the type of furnace with the aim of reducing emissions so that control device costs can be reduced. Three alternate choices would be electric arc, induction or reverberatory furnaces.

In 1968 the U. S. Department of Commerce News in a survey of 1,376 foundries, representing about 75% of all foundries, noted that 90% of the foundries surveyed used cupolas as the melting source. About 5% used electric induction, 3% electric arc, and 2% reverberatory furnaces.

The direct electric arc furnace melts the metal by a high energy arc established among three graphite or carbon electrodes inserted through the refractory lined roof of the furnace. The arc acts directly with the metal. During meltdown, the electrodes are positioned to maintain the arc. These furnaces have the advantage of rapid and accurate heat control, and can melt at about 10 tons per hour. Since no gases are used in the heating process, some undesirable metallurgical effects are eliminated, and the process is therefore frequently used where special alloys are to be made.

Indirect arc furnaces, as the name implies, melt via two electrodes, one located at each end of the furnace with the arc maintained above the charge. These furnaces usually melt at rates up to four tons per hour. As in the case of direct arc electric furnaces, they are most frequently employed in special alloying situations.

The electrodes used in forming the arc in arc furnaces are consumed in the melting operation at the rate of about 10 pounds for each ton of iron, forming CO, CO₂ and N₂ while oxides, mostly iron, are formed from the metallics.

An average emission of 19 arc furnaces cited in Reference 2 is 13.7 lbs per ton of charge, only about 25% less than that cited as cupola emission in Reference 17. It also appears that the size distribution is probably less favorable to control than cupola emissions.

In the electric induction furnace, an alternating current is passed through a primary coil. Eddy currents induced in the charge by the high flux density magnetic field result in heating of the charge by virtue of its resistance to the eddy currents. The more intense the magnetic field, the higher the frequency, the higher the melting temperature obtained. Induction furnaces are capable of sustaining high melt rates.

A gas or oil-fired reverberatory furnace operates on the same principle as an open hearth furnace in that the metal is exposed to hot combustion gases for melting. The furnace is nearly enclosed except for the charging hopper which is also the avenue for the discharged gases which are usually discharged via a hood and short stack arrangement.

Later sections deal with the utilization of reverberatory furnaces in small foundries. In the Philadelphia area, one of the three Pennsylvania areas studied, all of the remaining small foundries have changed to this type of melting.

Tests¹⁶ on the unit of one manufacturer for a charge of 1,100 pounds indicated 0.8 lbs. of particulate per ton of throughput using a reverberatory. This output is well within all of the Pennsylvania standards, including those proposed in the present implementation plan.

The main drawbacks to reverberatory furnaces are that a single furnace will have limited capacity, and the size and condition of scrap must be more

closely controlled than for a cupola. The authors know of only two or three furnaces of two tons per hour capacity installed in the United States. This appears to be the melt rate limit for their use in gray iron foundries. The refractory material also must be frequently replaced. In addition, there is a learning process for the foundry which turns from long familiarity with cupola operation to a different type of melting requiring somewhat different techniques and possessing new metallurgical problems.

Nevertheless, the low acquisition cost without the need for control devices makes this an attractive alternative for foundries melting four tons per hour or less, and therefore the use of such furnaces is growing quite rapidly in the small foundry, with about 60 presently installed.

1.6.3 Limitations on Production Volume

As discussed in Section 1.4.3 the regulations in Pennsylvania will be common on a statewide basis, and as far as foundries are concerned will be based on melt rate, although, as will be seen in later sections, melt rate for small foundries is not highly correlated with blast rate. Total emissions are highly correlated with blast rates and iron-carbon ratios.

Many small foundries melt for only a few hours a day. The foundries visited in this study typically started to melt at 11:00 A.M. and poured at about 1:00 P.M. Since there is no time dimension except hourly rate in the Pennsylvania code, a foundry could consider spacing out its melting operation. For example, referring to Figure 1-6, and using the associated Table 1-A, a foundry operating at four tons per hour would have an allowable hourly rate of 5.8 lbs. The same foundry, if operating at two tons for hours per day, would have an allowable hourly rate of 4.4 lbs. If each plant, using emission

factors of Reference 17, is emitting 17 lbs. per hour uncontrolled emissions, the two efficiencies are:

$$\text{Plant @ 4 tons/hr.} \quad \frac{68 - 5.8}{68} = 91.5\%$$

$$\text{Plant @ 2 tons/hr.} \quad \frac{34 - 4.4}{34} = 87\%$$

Thus, although exactly the same total particulates are emitted in a 24-hour period, the lower melt rate cupola requires less performance efficiency, and hence the collector, if a wet scrubber is used, will need significantly less pressure drop. This, as will be seen in Section 2, would have very salutary effects on equipment acquisition and operating expenses, but would require schedule and layout changes.

Reducing the melt rate cannot be accomplished merely by attempting to process less charge per unit time. To do this, the cupola must be necked down by installing additional refractory lining. For example, a No. 6 cupola could be lined down to a No. 3 cupola having about 1/2 the melt rate by adding refractory lining to the inside diameter of the cupola to reduce the diameter from 48 to 32 inches.

By this method, the cost of the associated control equipment can be reduced but not eliminated. The savings on device acquisition and operating cost must be compared to the costs of lining, plus what might be serious impacts on the overall foundry efficiency. Size of cast parts, floor space, work flow, operating force and other industrial engineering factors were probably optimized for the existing melt rate so that departures from this could create severe plant efficiency problems, especially in cases where the

plant makes larger castings whose individual weight is 10% or larger of the melt rate. Also, if demand for castings increases, a plant may want its production capability back without resulting to multi-shift operations. For these reasons we have not used this alternative in developing group commonalities.

2. Variability of Costs With Process and Equipment Parameters

In this section, Section 2, the variability of system costs with process and equipment parameters is examined. Such an evaluation is necessary to set optimum performance specification bounds when identifying potential foundry groups.

2.1 Description of Cost Components

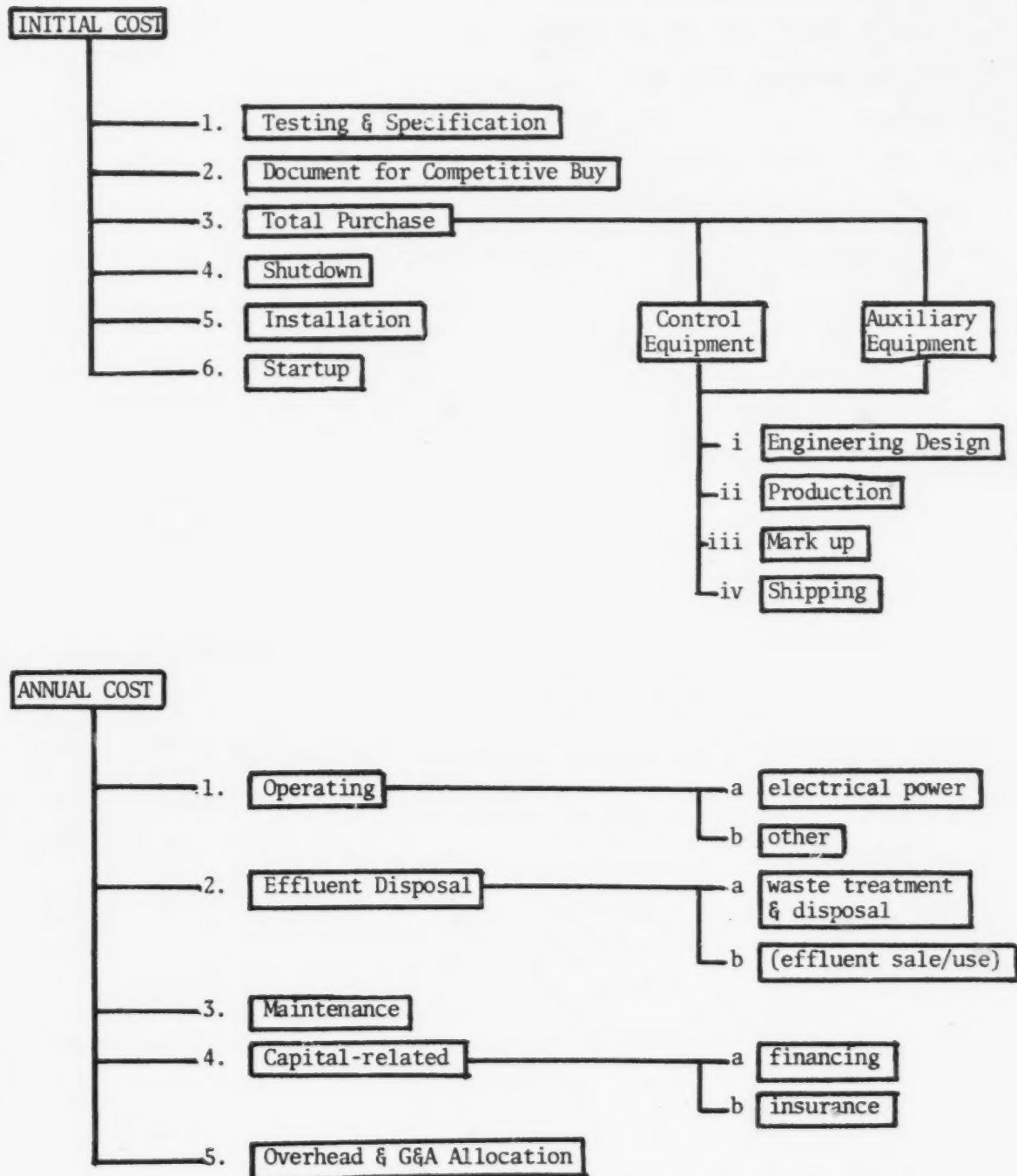
Before analyzing the costs of control equipment, it is necessary to identify and define the various components that make up these costs. Much of the literature on this subject is difficult to comprehend and use, principally because of ill-defined cost components. In addition, no two sources of cost information use the same mode for reporting equipment costs. This makes any actual cost comparison between different control devices difficult.

The mode of analysis of costs depends to a large extent upon where the results of such analysis might be applied. The same equipment may be looked at, for example, from an economic or an accounting point of view.

An analysis primarily intended for economic application selects the most practical useful life and allocates the cost equally over this period. (In this instance, many times a different useful life is assumed by different reporters.) An accounting analysis depreciates the initial cost over the accounting life of the equipment by any of several methods chosen to optimize operation of the company. The practical useful life for economic analysis and the depreciation period for accounting purposes

Table 2-A

COMPONENTS OF POLLUTION CONTROL COSTS



may be significantly different as would the methods of spreading the costs so that these differing modes give rise to differences in annual costs.

To remove ambiguity from these two sources, namely cost components and mode of analysis, we have carefully defined the components of initial and annual costs in Table 2-A. Tangible costs incurred before and during startup of the control system are referred to as initial cost. All components of this initial cost can, in general, be capitalized. These costs are incurred as a direct result of the installation of the control system for its use in the manufacturing process. The initial cost is made up of six separate components, listed roughly as they would occur chronologically in a typical installation.

Because of the problem of differences in spreading the initial cost, the reader will note that annual cost includes no depreciation allowance among the five cost components defined.

2.1.1 Initial Costs

Referring to Table 2-A, Testing and Specification includes such items as initial stack sampling, evaluation of the effectiveness of the proposed control equipment required for compliance, and other process evaluation related to pollution control. Document for Competitive Buy includes costs incurred in the preparation of bidding documents, asking for bids and evaluating them, deciding upon the supplier, and in preparing the contract. Total Purchase Cost includes the FOB cost of equipment plus shipping charges, for both the control equipment and the necessary auxiliaries. The Purchase Cost may be subdivided, from the manufacturer's point

of view, into four components listed in Table 2-A. Shutdown Costs develop from interruption of production during installation. Installation Costs include foundation preparation, rigging, and installation or relocation of utilities. Startup Costs are incurred during the initial matching and testing required to bring the new equipment into use, including compliance testing. Addition of the equipment to an existing process may also modify the performance of the present industrial process so that the entire operation must be "retuned".

2.1.2 Annual Costs

Annual Costs are divided into five components on the basis of cost centers. Electrical power and material used during the operation of the equipment give rise to Operating Costs. Since most control devices develop secondary pollution problems, the treatment of the waste effluent from the device involves Effluent Disposal Costs. If the effluent collected can be used, recycled or sold for economic gain, this offsets the disposal cost. The machinery and the structure of the device will require periodic maintenance during its useful life. Capital-Related Costs are those of financing (even if the equipment was bought for cash, an implicit interest cost is still a part of the annual cost) and equipment insurance. Overhead, general and administrative expenses attributable to the control system make up the fifth component of annual costs.

2.2 Process Variables

The chief melting process variables that effect the design and

performance of the pollution control system are:

Particulate loading

Volume flow rate of gas

Exit gas temperature

Chemical composition of exit gas

2.2.1 Particulate Loading In Gas

It has been mentioned in Section 1 that several factors - cleanliness of scrap used in melting, degree of pulverization of the coke used, and presence of after-burning for complete combustion - influence the amount of particulate effluent, but not in an analytically predictable fashion. Particulate concentration -- effluent per unit of gas volume -- is affected further by the volume flow rate of gas and the draft addition of atmospheric air through the charge door. Mass distribution of particle size is also a process variable, again with low correlation with other factors.

2.2.2 Volume Flow Rate of Gas

The combustion of coke to yield desired temperatures at the melting zone necessitates the addition of blast air. Blast volume - melt rate capacity relationship for the cupola is analyzed below in Section 4. Gaseous products of combustion add typically 15 percent of blast volume to the gas leaving the melting zone⁹. Draft flow of air through the charge door, caused by the static pressure differential across the door, is dependent on wind direction and speed, and on the temperature difference

across the door. A figure of 300 ft/min is used for draft velocity through the charge door in design calculation⁹. Volume flow rate is obtained by multiplying the above figure by the charge door area in square feet.

2.2.3 Exit Gas Temperature

The temperature at the melting zone is typically of the order of 2,700°F. The temperature desired depends upon the kind of iron produced, since higher temperatures increase the carbon content of the molten metal. This temperature increases with decreasing iron-carbon ratio⁵. It also increases with increasing blast volume for a given cupola. Afterburning increases the gas temperature. After mixing with air from the charge door, the temperature is reduced to about 1,200-1,600°F.

2.2.4 Chemical Composition of Exit Gas

Exit gases contain varying amounts of nitrogen, carbon dioxide, carbon monoxide and sulfur oxides. Controlled combustion and afterburning reduce the percentage of carbon monoxide in the exit gas.

2.3 Variability of Costs With System Variables

As stated in Section 1, this study will concentrate upon the wet scrubber and the fabric filter as the alternative ways of cleaning the cupola stack gases. Section 2.3 discusses the effect on various components of initial and annual costs, of pertinent system variables.

2.3.1 Collection Efficiency of the System, Effluent Rate

As mentioned above, particulate loading in gases from melting is a process variable. Depending upon the way in which the compliance laws are designed in a particular region at a particular time, the maximum allowable emission from a stack is expressed either as effluent rate (pounds of particulates per hour) or as effluent concentration (grains of particulates per standard cubic foot of stack gas). In either form, the maximum allowable emission level is determined by factors such as the process weight (i.e., the melt rate), effective stack height, etc., and the pertinent emission control regulation. The proposed Pennsylvania regulations limit process emissions in terms of effluent rate.

Effluent rate and effluent concentration are related by the following equation

$$M = G \times V$$

where M = the effluent rate

G = the effluent concentration

V = the standard volume flow rate of gas through the system.

Collector performance is usually stated in terms of collection efficiency, which may be calculated from:

$$\text{Efficiency (\%)} = \frac{M_i - M_o}{M_i} \times 100,$$

where M_i = the contaminant mass flow rate at the collector inlet

M_o = the contaminant mass flow rate at the collector outlet.

For the wet scrubber, efficiency is a strong function of particle size, the efficiency decreasing sharply with a reduction in particle size. Figure 2-1 shows the theoretical efficiency-particle size relationship for a certain wet scrubber at a given pressure drop across the scrubber. (Actual source measurements have indicated efficiencies somewhat less than the theoretical predicted efficiencies.) Thus, the outlet mass flow rate of the effluent is determined from the inlet mass flow rate, the fractional efficiency characteristic of the scrubber, and the inlet mass distribution of the particle size. The overall efficiency of the unit may then be determined using the above equation. The larger the relative amount of small particles in the inlet, the lower is the overall efficiency of the unit, and larger is the outlet effluent rate.

For given inlet conditions, overall collection efficiency is a function of the pressure drop across the scrubber. The pressure drop is determined by the resistance to gas flow through the scrubber, as through the throat in a venturi scrubber, and the amount of contact between the gas and the liquor used as the collection medium. Figure 2-2 shows the relationship between overall collection efficiency and pressure drop for a typical scrubber operation for cupola gas cleaning.

An increase in the required collection efficiency increases the design pressure drop. Greater pressure drop results in higher horsepower needs which are reflected in greater initial (purchase) costs for the motor, starter, blower, wiring, controls, and all other related components.

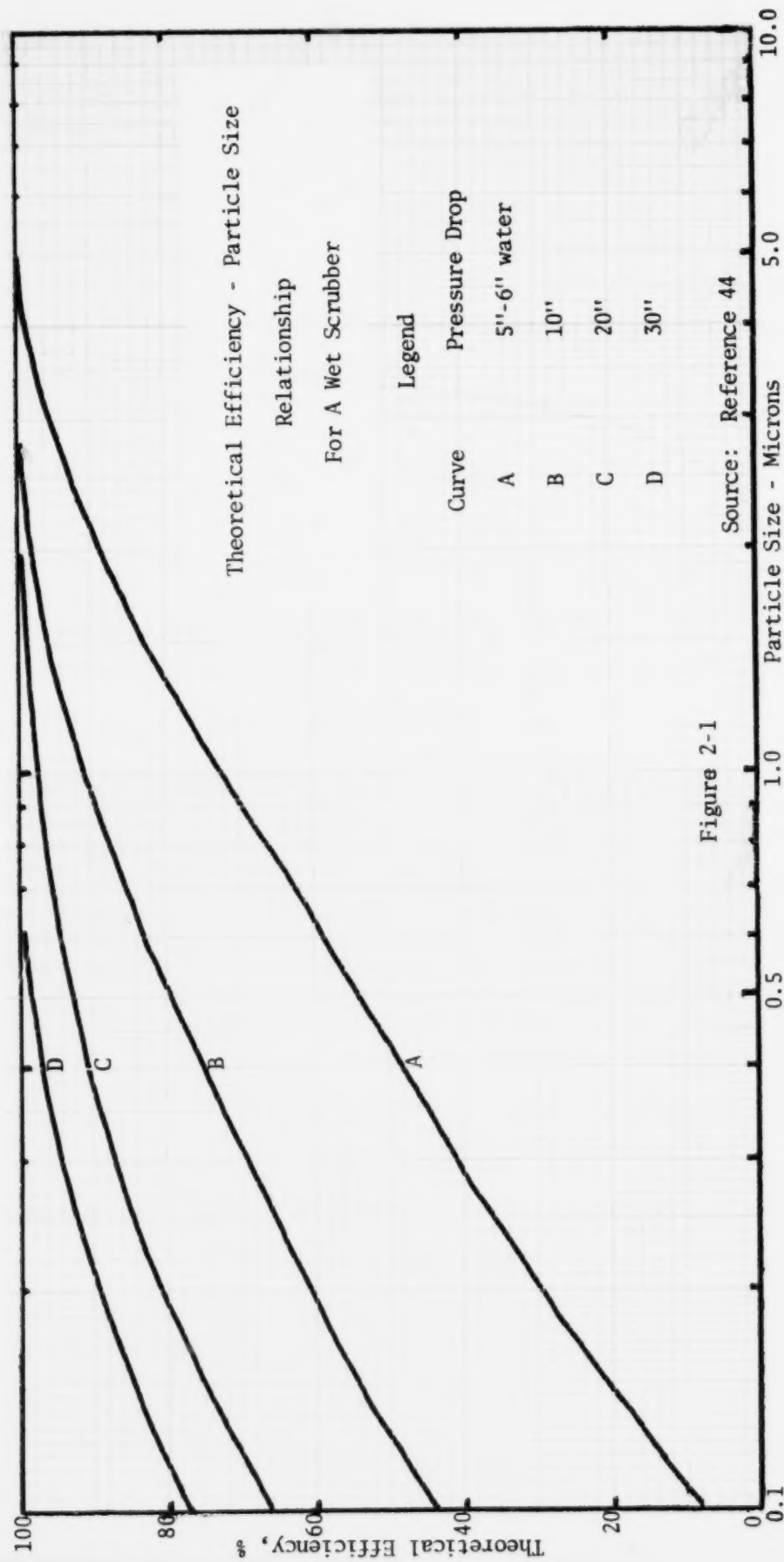
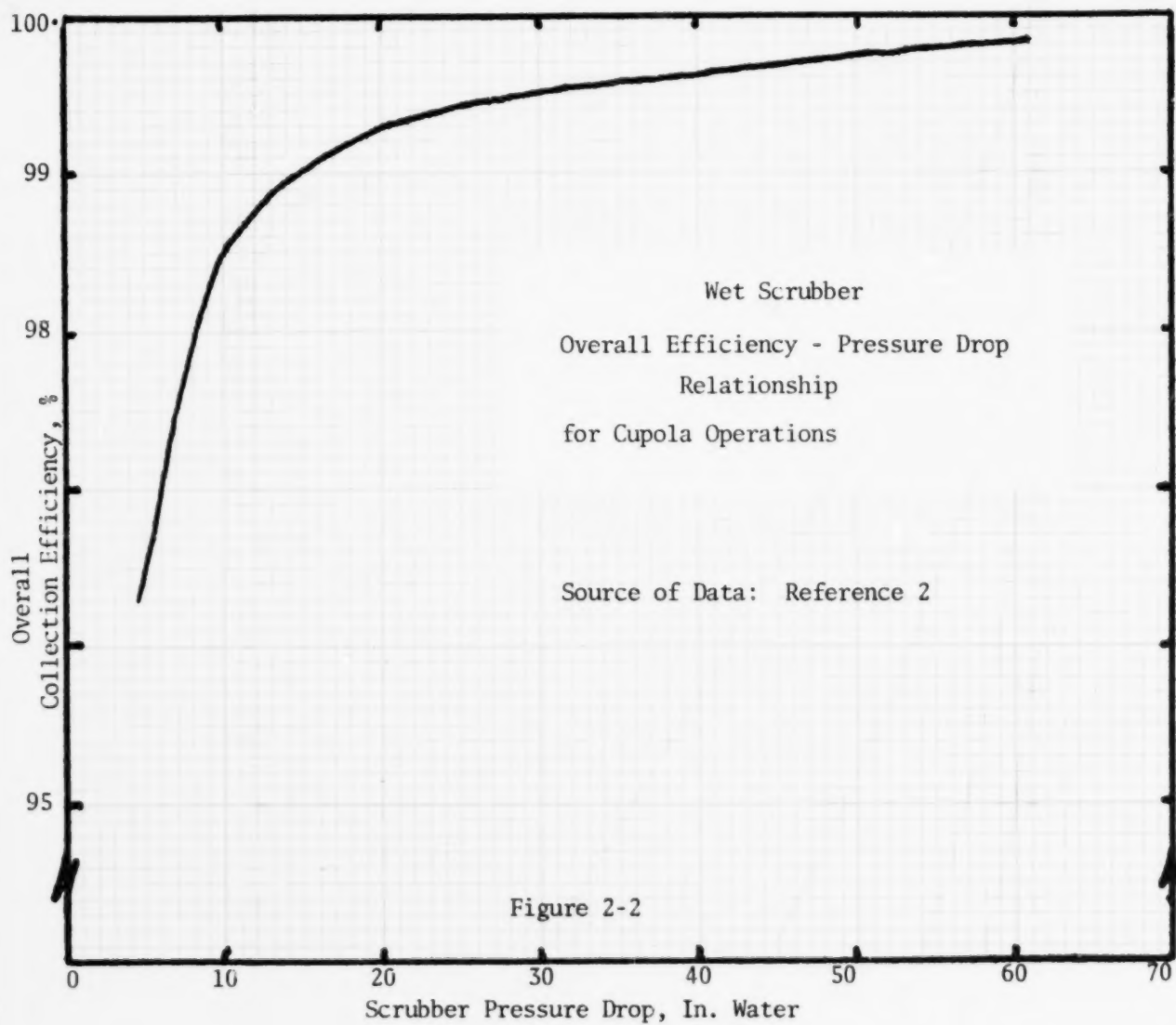


Figure 2-1



The aggregate effect of all of these added costs to the acquisition cost of the control equipment can be readily seen in Figure 4.4 of Section 4 which depicts added costs versus output grain loading at fixed temperatures, gas volume, and input grain loading.

The increased energy requirement with an increase in the pressure drop also affects the operating cost of the wet scrubber. Figure 2-3 shows the variation in normalized annual costs with pressure drop for wet scrubbers. The theoretical annual cost⁷ of operation and maintenance (G) for wet scrubbers can also be determined from

$$G = V [0.7457 \text{ HK} \left(\frac{P}{6356E} + \frac{Qg}{1722F} + \frac{Qh}{3960F} \right) + \text{WHL} + M]$$

where V = design capacity of wet scrubber, acfm

0.7457 = a constant (1 hp = 0.7457 kw)

H = annual operating time, hours

K = power costs, \$/kwh

P = pressure drop across scrubber, inches of water

Q = liquor circulation, gallons per acfm

g = liquor pressure at collector, psig

h = physical height liquor is pumped to, feet

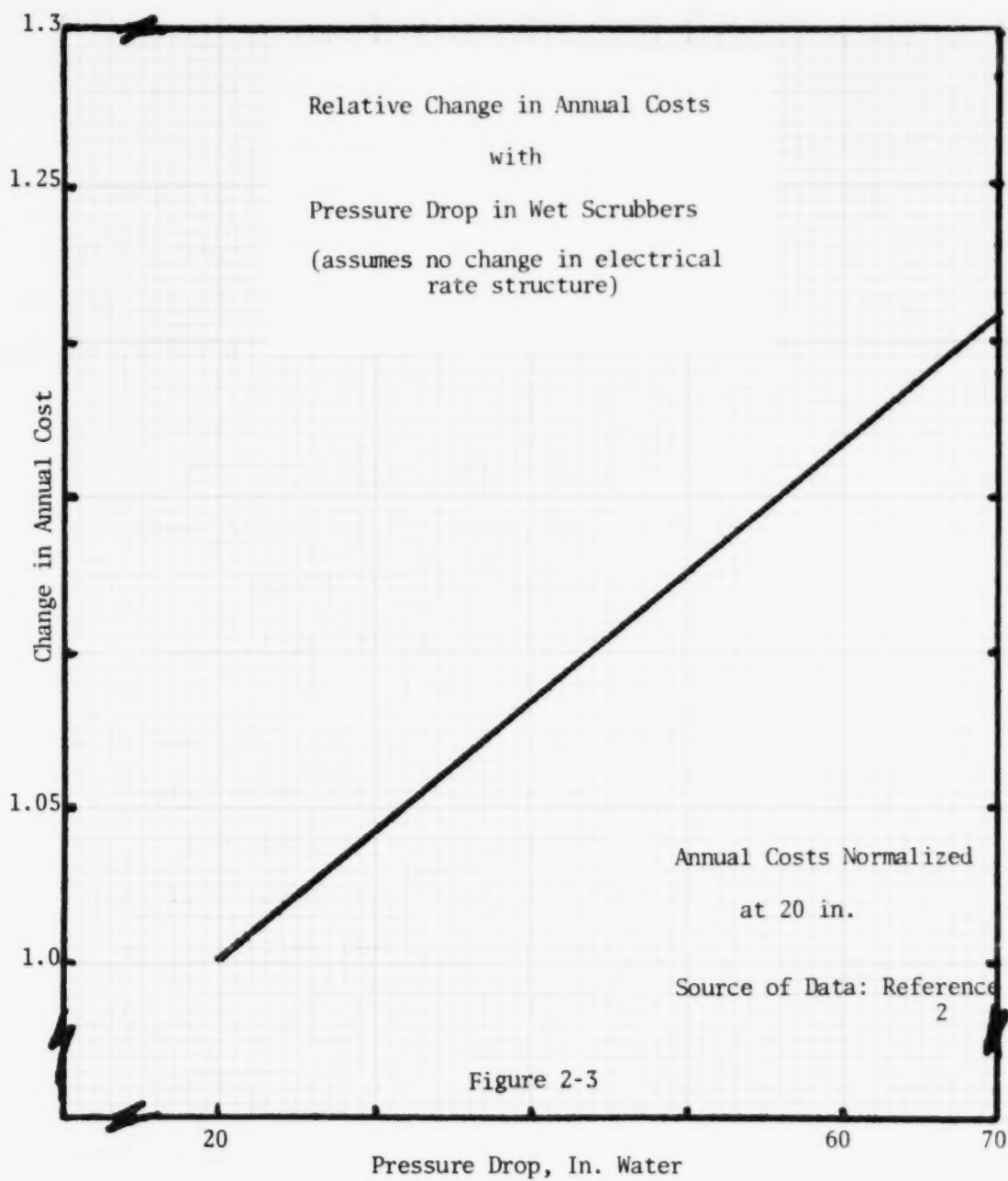
W = makeup liquor, gallons per acfm

M = maintenance cost, \$/acfm

E = fan efficiency

F = pump efficiency

Typical values of the various factors for high-energy scrubbers are listed in Reference 7. For a scrubber operating for 1,000 hours annually



with 50,000 acfm of gas, an increase in the pressure drop by 1 inch would increase the annual costs by \$150 from the above equation. The above equation does not include the demand costs of electrical power, which for a small foundry with only a few hours melt per day may be a significant factor.

For the fabric filter, strong functionality between efficiency and particle size does not exist. It is capable of being virtually 100% efficient over the submicron range of particle sizes with the proper choice of fabric and air/cloth ratio. Thus the particle size distribution does not enter into fabric filter performance as a process variable. Variations in fabric filter costs are due to other parameters, as discussed below.

2.3.2 Gas Flow Rate

The relationship between cupola melt rate and blast volume is discussed in Section 4. Gaseous products of combustion, infiltrated air through the charge door, and steam generated in the gas conditioning quenching unit add to the amount of gas that is to be treated by the collector, and are a significant design and performance parameter of the collection system. For example, the gas flow rate affects the optimum throat velocity on a venturi scrubber.

Variations from the design flow rate in the range +7% to -20% are typically allowed for scrubbers. The liquor flow rate and the throat opening are varied to accommodate such variations without affecting the performance. (Variable throat controls typically add \$1,500 to the cost of the system).

Not only does the gas flow rate have a bearing on the venturi design, but it affects other components of a wet system.

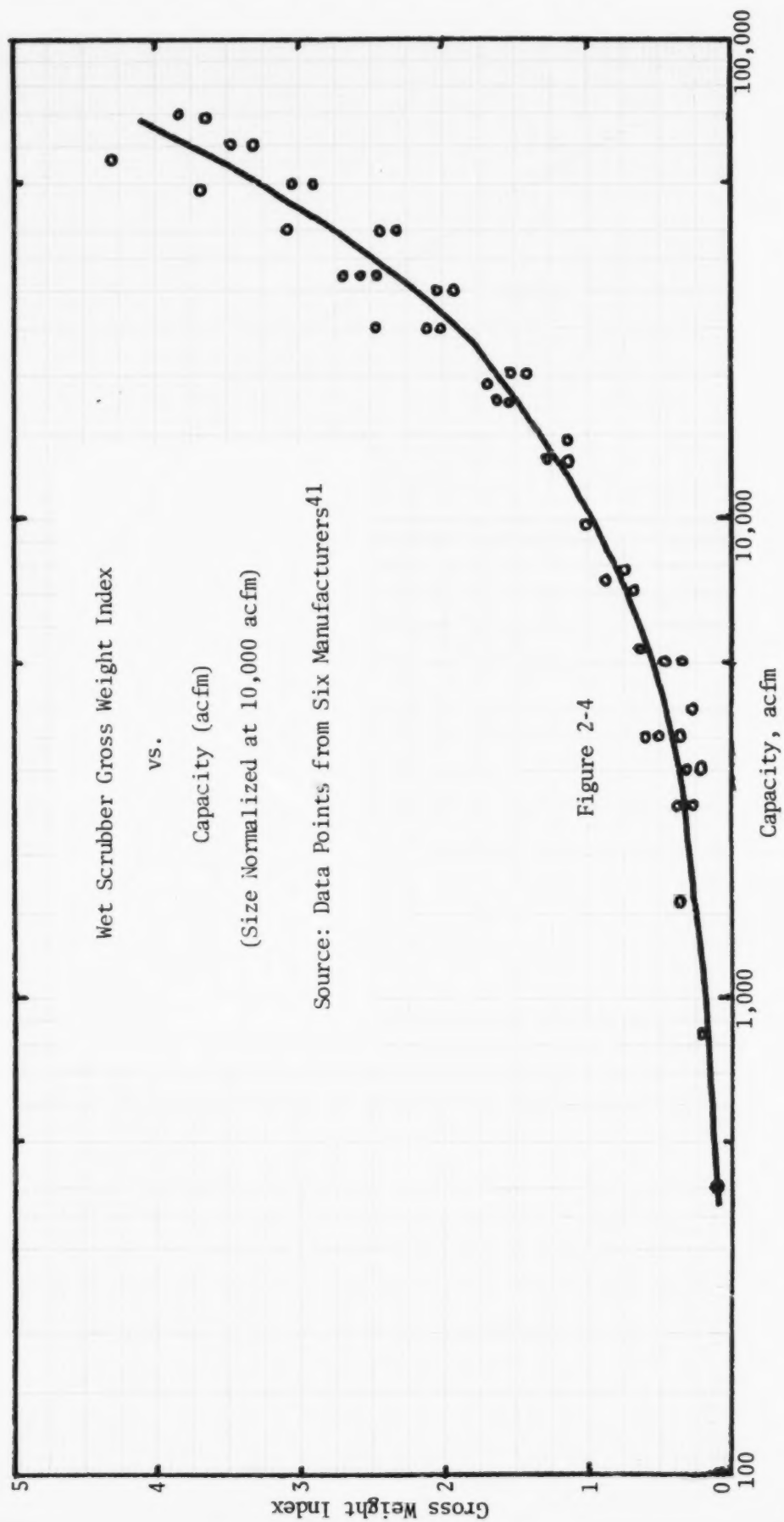
The entrainment separator (demister) is designed to remove liquid droplets of 10-25 micron size by imparting a centrifugal force to them. Interaction between the axial velocity and the radial (centrifugal) velocity causes the droplets to move toward the wall of the separator. The axial dimension of the unit is designed for effective separation for a certain axial velocity. For higher flow rates, the size of the separator increases, for the same separation effectiveness of droplets.

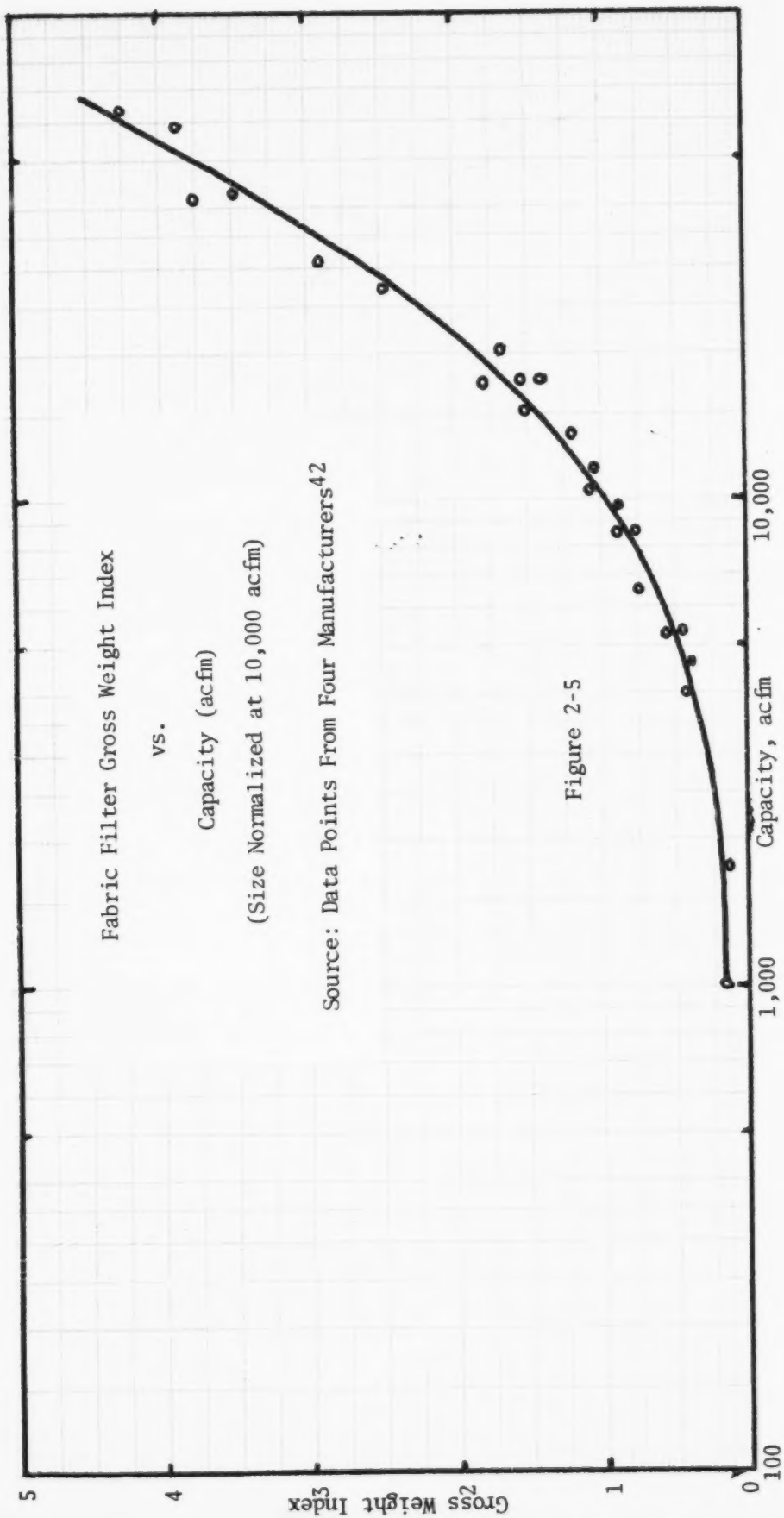
Fabric filter selection is in part based on the air/cloth ratio, defined as:

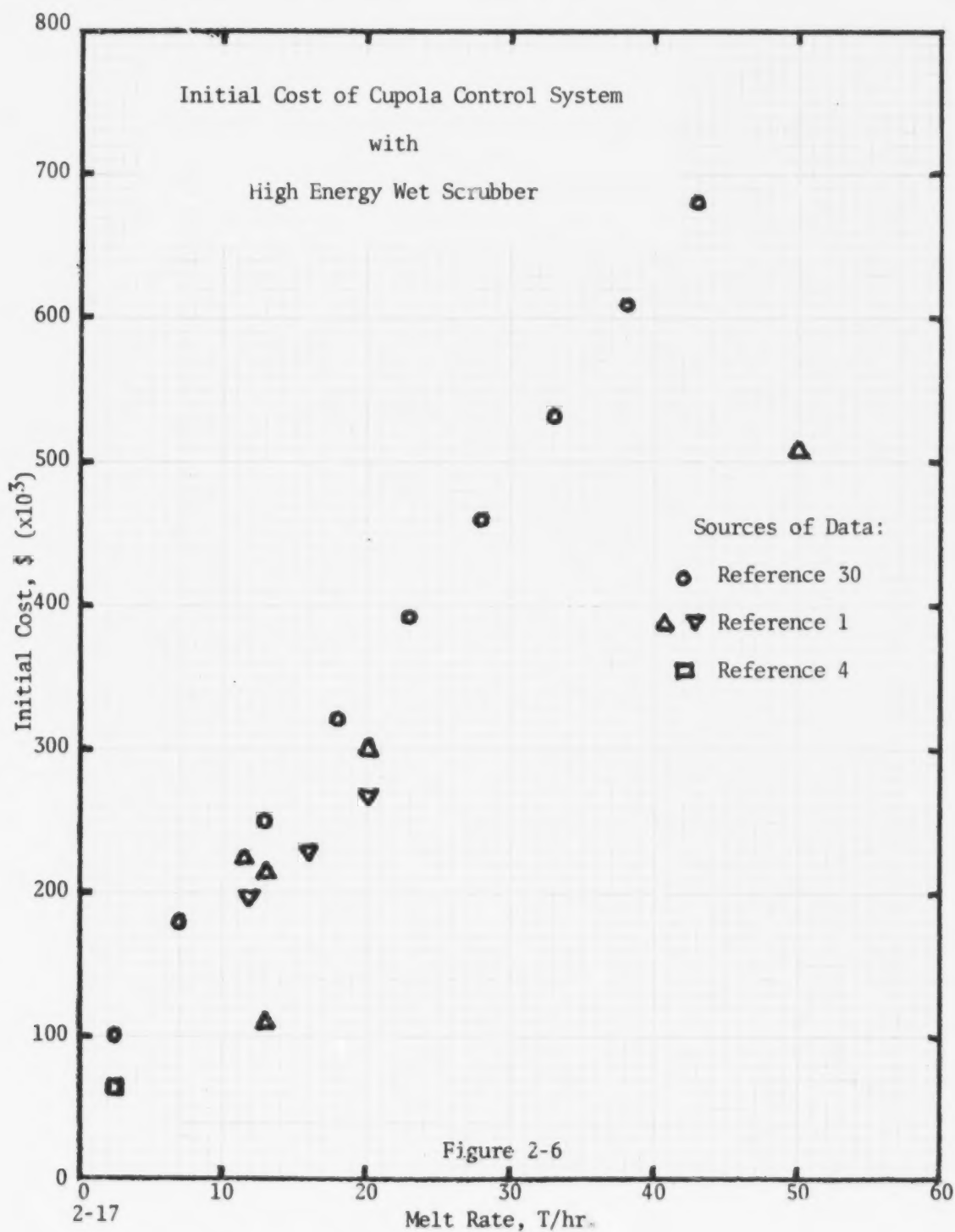
$$\text{air/cloth ratio} = \frac{\text{gas flow rate, acfm}}{\text{net filter area available, ft}^2}$$

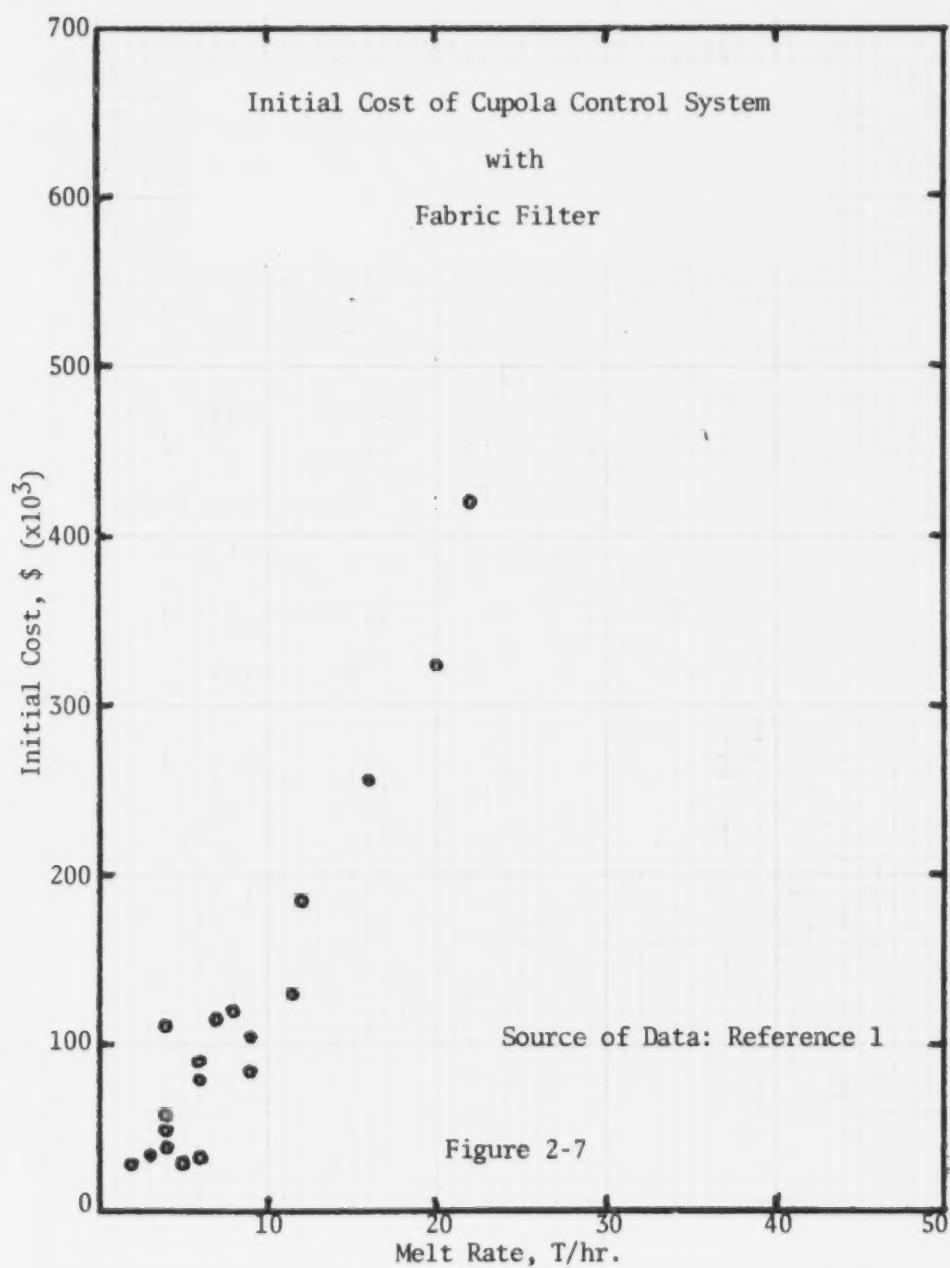
Depending on various physical characteristics of the particles, optimal values of air/cloth ratio ranges are available for different fabric filter applications. In asphalt-batching applications, for example, the recommended air/cloth ratio is about 6.5. For cupola emission control, the typical value is 2.5. The greater the flow rate at a given air to cloth ratio, the greater the number of bags, the larger the housing, and the more numerous the controls and actuating mechanisms.

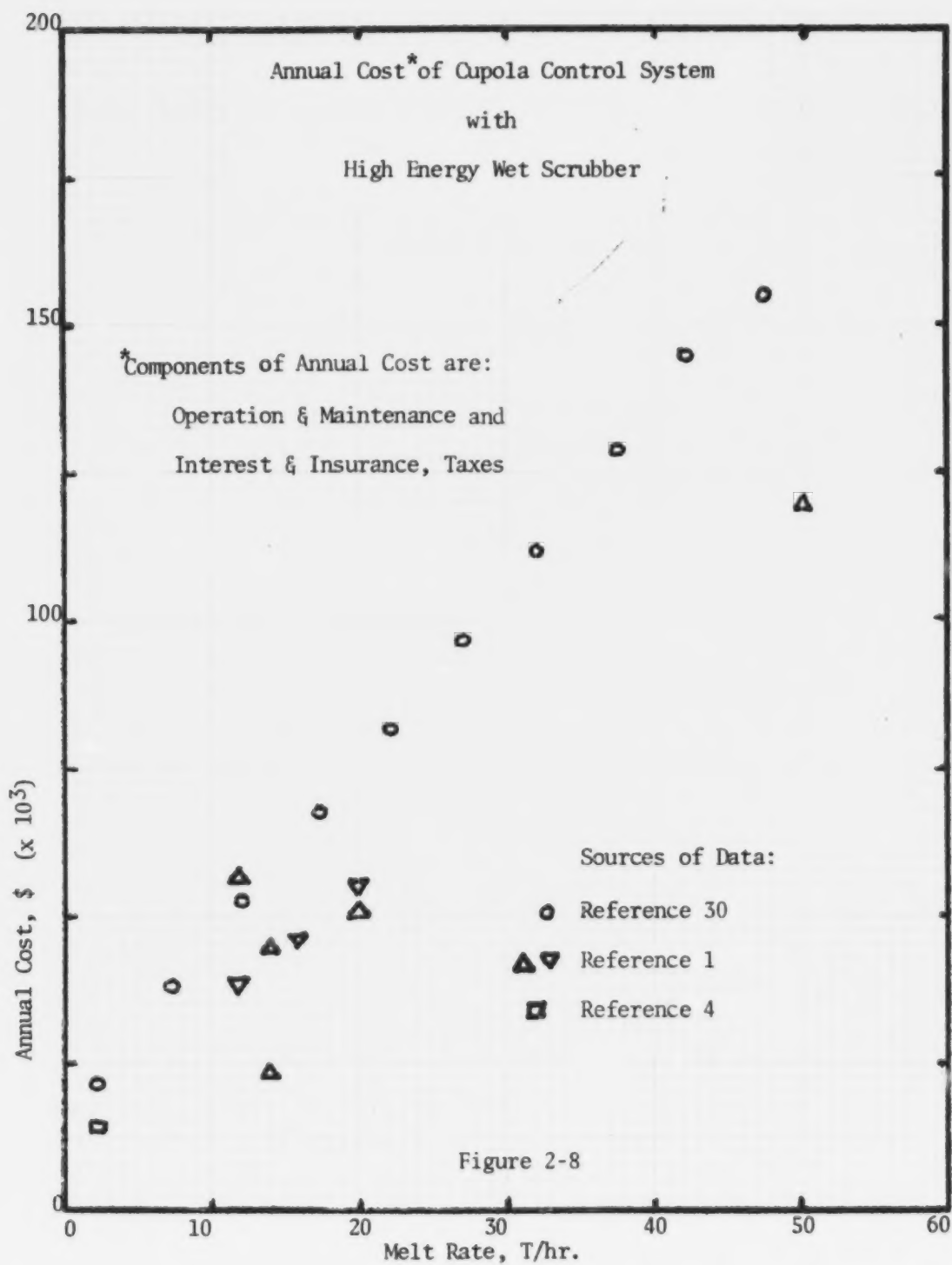
Since part of the reason for increases in both initial and annual cost of both a venturi scrubber and a fabric filter, due to increases in gas volume, is attributed to direct increases in size of the unit to handle the increased gas flow, it is therefore interesting to relate flow rate to a

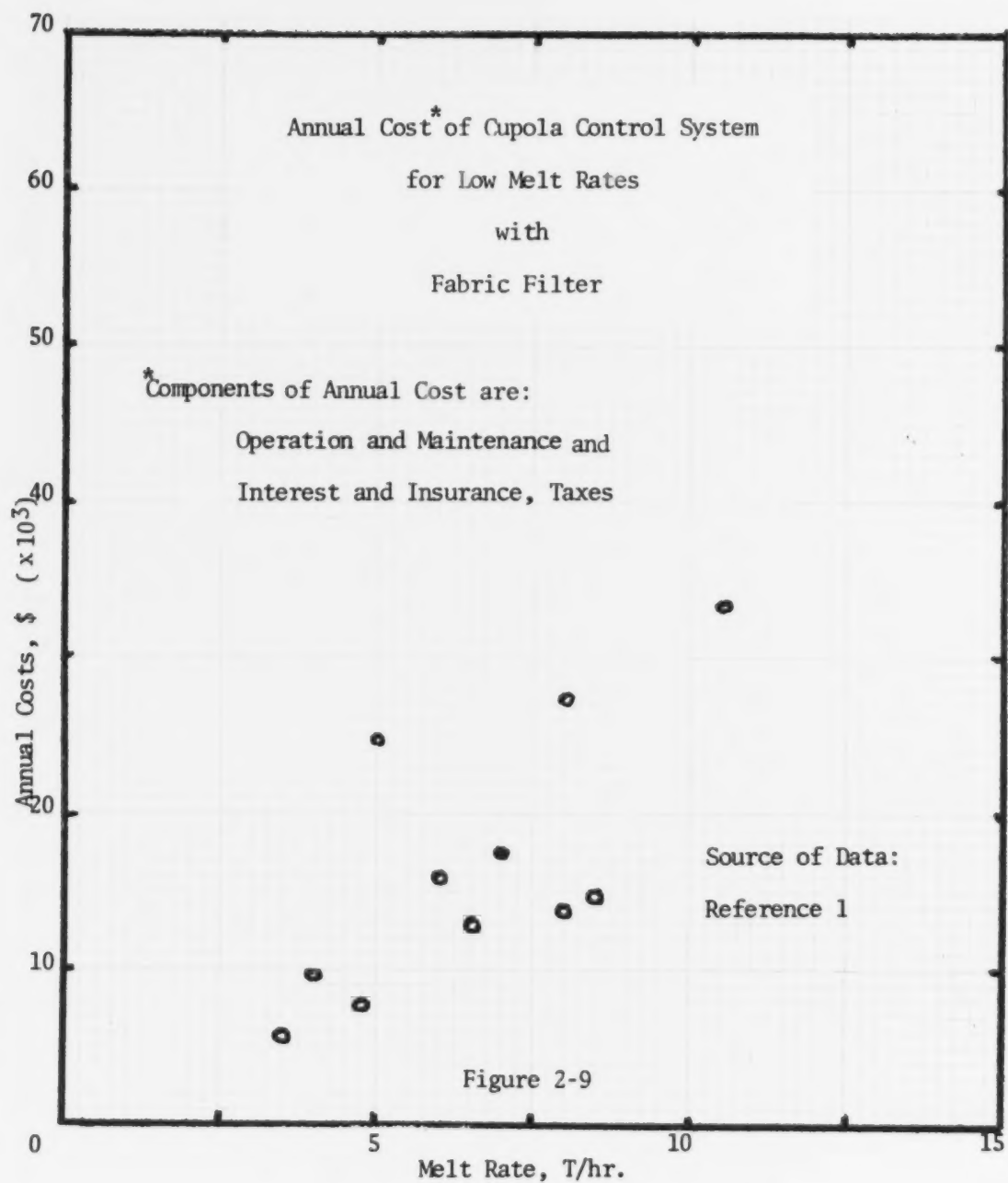












typical linear dimension of the unit, its volume or its gross weight. If developed on both a volume and weight basis, some rule of thumb on supports and costs might be determined although this was not pursued to completion in this study.

Figure 2-4 shows the effect of flow rate on the gross weight of a wet scrubber. The gross weight is normalized to 1.0 at a design flow rate of 10,000 acfm. The same relationship is plotted for the fabric filter in Figure 2-5. A five-fold increase in capacity from 10,000 to 50,000 acfm roughly triples the size of the wet scrubber; the increase in size is slightly greater for the fabric filter.

One way of relating capacity in scfm to costs is through the cupola melt rate capacity. Figures 2-6 and 2-7 show the variation of initial costs with melt rate for the wet scrubber and the fabric filter, respectively.

The theoretical equation for scrubber operating and maintenance costs listed above suggests a linear relationship with gas volume. A similar equation is listed in Reference 7, for the fabric filter:

$$G = V \left[\frac{0.7457}{6356 E} PHK + M \right]$$

where the various symbols have meanings attached as before.

Figures 2-8 and 2-9 relate annual costs with melt rate for the wet scrubber and the fabric filter, respectively. The data shows a large variation due to different sources, and different experiences with control devices by users.

2.3.3 The Charge Door

Since the volume flow rate entering the control device is materially increased by the draft through a conventional charge door, a substantial change in both initial and annual costs of the two gas cleaning systems is seen from Figures 2-10a through 2-13a. In each figure, a comparison is made of the pertinent costs for two designs: gas takeoff above charge door (with volume flow rate to be treated increased by the amount of air through charge door), and gas takeoff below charge door. Further implications of the charge-door draft air are discussed in Section 4.

2.4 Control Cost Components

A recent study² noted that the control device and auxiliary equipment costs for wet scrubber control units averaged 66% of the initial cost with a variation between 48 and 85%. For a fabric filter, the average equipment cost is 65% of the initial cost with a variation between 41 and 82%.

Figure 2-14 shows a typical distribution of annual costs of a fabric filter unit, and Figure 2-15, the costs for a wet scrubber based on 53,000 acfm, a 50-inch pressure drop, and 800 hours of operation per year.

2.5 Comments On Accuracy Of Cost Data

The preceding analysis of the variability of costs with system parameters describes both the absolute cost in dollar amounts as well as the relative change of the various costs on a normalized basis. The latter approach is probably of greater utility in determining the relative effects

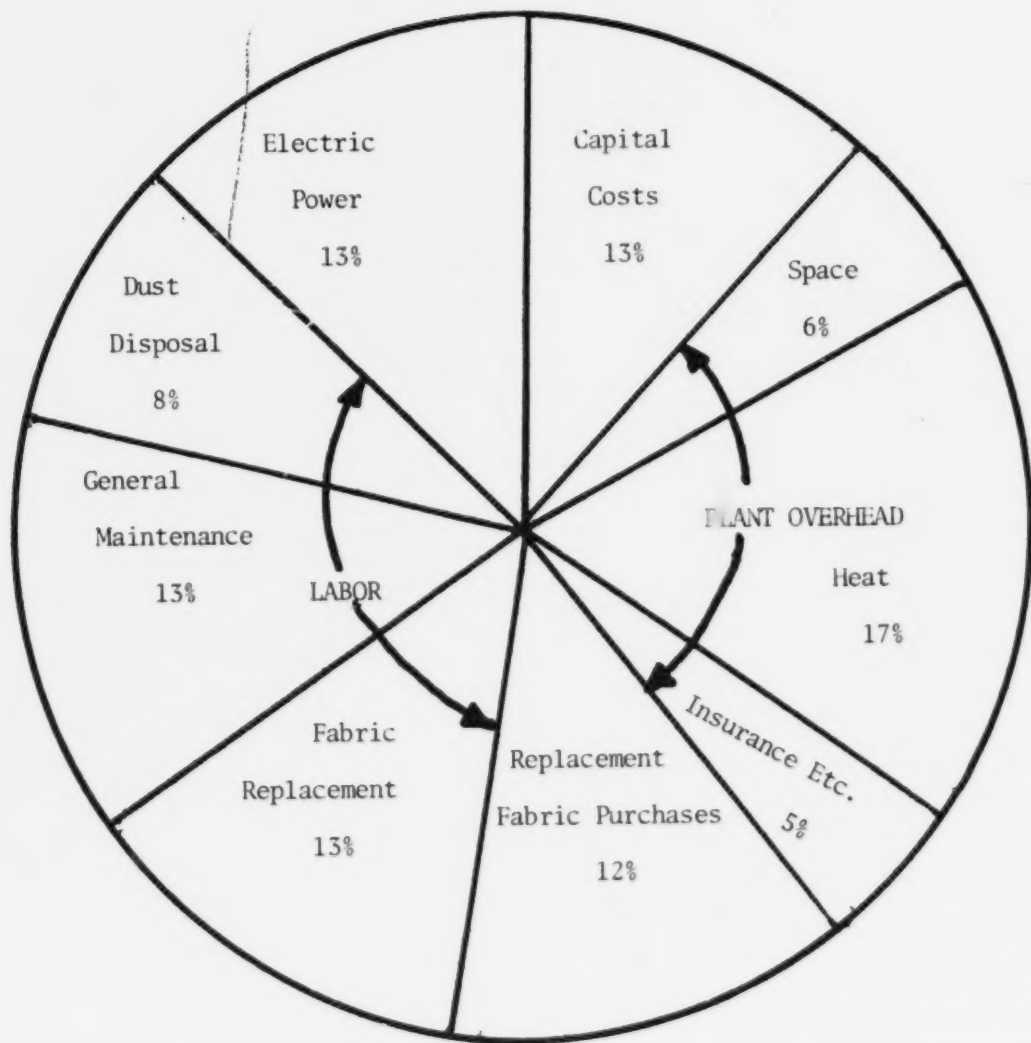


Figure 2-14
Fabric Filter Annual Cost Distribution

Source: Reference 10

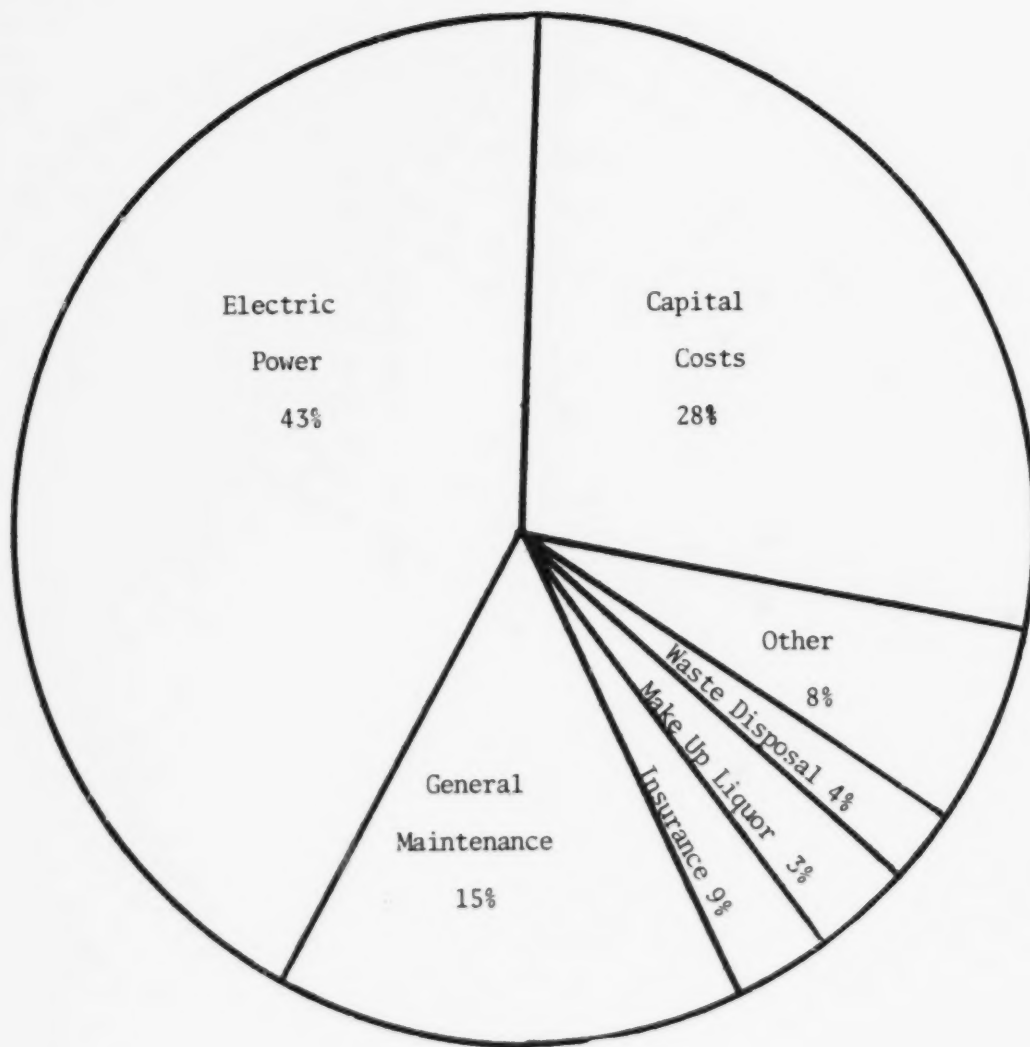


Figure 2-15
High-Energy Wet Scrubber Annual Cost Distribution

of parameters on initial system costs because the inherent inaccuracies in the reported data have a less adverse effect. Since, as noted above, and in Section 4, initial cost includes an installation factor of about 35% which varies from plant to plant over a nearly 2 to 1 range, any cost comparison of the whole system for non-identical plants will be, therefore, subject to variance.

Other factors such as a lack of good cost accounting systems in many operations and actual variations in unit costs of labor, power, etc., increase the variance in reported costs. The data, therefore, should be used best for order-of-magnitude studies, and for relative effects of parameters on various costs.

3. Variability of Costs with Financing Alternatives

As shown in Section 4 of this report, the financial outlay which a foundry melting on the order of 10 tons-per-hour must make to achieve air pollution control is in excess of \$100,000, a very substantial capital investment, perhaps a sizeable fraction of its net worth. With the useful life of an equipment in excess of ten years, yearly interest payments have as important an impact on company finances as yearly principal payments. These costs have, as will be shown in this section, wide swings based on financing methods utilized.

The methods through which the necessary funds can be obtained under the above-stated circumstances can be divided into three broad categories. One method - and the one which probably comes most readily to mind - involves straight bank borrowing. In this case, as discussed more fully below (Section 3.2), the foundry's eligibility for such borrowing in terms of financial strength, may pose a problem.

A second method involves simply paying for the equipment out of the foundry's own funds, generated through its operating cash flow. This method is, of course, only available if that cash flow is sufficiently positive to absorb the negative flow generated by payments on the new equipment.

A third method is predicated upon certain aids to industrial financing available from the government. As explained more fully hereafter (Section 3.3), there are methods involving the intervention of special government-created agencies which enable the foundry to have access to sources of financing which would, as a practical matter, be otherwise closed to them.

In the sections of this report which follow, these various methods are examined in detail and compared as to their costs and other fiscal operating implications. (For the sake of easy following, \$100,000 is used as the capital outlay rather than the somewhat larger figure for a 10 TPH plant noted in Section 4.) Readers of this report familiar with financing matters will, of course, recognize that the foregoing categorization of possible financing methods does not exhaust the possibilities. For example, equipment leasing as a method of financing has not been mentioned above. Financing by the equipment manufacturer has not been posed as an explicit possibility, nor has factoring, and so forth. The reason for this is that we have endeavored to treat that assortment of possibilities which most clearly reflects the time costs of financing. Thus, leasing as a financing vehicle, for example, tends to obscure the cost of financing, per se, because the lessor, in turn, must obtain his funds elsewhere and the costs to the lessee, therefore, reflect the cumulative costs of the funds themselves, and of the lessor's operating costs and profit. Borrowing directly from a bank, in contrast, does not have this additional ingredient, but reveals the basic financing costs, as such.

3.1 Methods Used In Analyzing Financing Costs

In order to determine the cost to the foundry of the various available methods of raising funds, it is necessary to analyze the effect of such a venture on the foundry's operating financial position: its net profits after taxes. This and the next section, 3.1.1, describe the methodology used in the subsequent comparisons.

A comparison of the after-tax profits with and without the financing makes it possible to quantify and analyze such an effect: net annual profit after taxes, P, and the tax liability, L, can be related to other operating parameters by the equation:

$$P = p (1-T) \qquad L = p T$$

where, p = annual taxable income
and T = the tax rate, expressed as a fraction.

The annual taxable income is related to the interest expense for the year by,

$$p = Q - I$$

where, Q = the operating income
and I = the interest expense

combining the above two equations,

$$\begin{aligned} P &= (Q - I) (1 - T) & L &= (Q - I) T \\ &= Q (1 - T) - I (1 - T) & &= Q T - I T \end{aligned}$$

If there was no interest expense during the year, $I = 0$, and the above equations become:

$$P = Q (1 - T) \qquad L = Q T$$

Thus, the effect of interest expense I is to reduce the net profit after taxes by $I (1 - T)$. The tax liability is reduced by $I T$.

If C is the amount of principal that is paid back during a year, and I the interest expense incurred as a result of the loan, the net cash out-

flow, NCF, is the net of cash outflows and the reduced tax liability (or tax savings):

$$\begin{aligned} \text{NCF} &= (C + I) - (I T) \\ &= C + I (1 - T) \end{aligned}$$

The above equation represents the net effect of the loan on the foundry's cash balance during a year.

3.1.1 Present Value Analysis

The payment of interest and principal payback extends through the term of the loan, which is defined as more than one year for a long term loan.

The net cash outflow, NCF_i during year i is given by:

$$\text{NCF}_i = C_i + I_i (1 - T), \quad i = 1, 2, \dots, n$$

where, C_i = principal payback during year i

I_i = interest expense during year i

n = term of the loan, years.

The total effect of the loan on the foundry's cash flow is determined by using the present value approach which utilizes the concept of time-value of money: A dollar spent today has a greater long-term effect on the financing situation of an enterprise than a dollar spent a year from now, because the dollar that was spent today has the potential of yielding a return if invested or saved. Thus, at the end of the year, the future value of today's dollar is,

$$\text{FV} = 1 + r$$

where, r = yield (interest earned) on one dollar.

The present value of the dollar spent a year from now is, on the other hand,

$$PV = \frac{1}{1 + r}$$

which is less than 1.

The present value of a dollar spent i years from now is obtained by discounting annually:

$$PV = \frac{1}{(1 + r)^i}$$

Thus, the present value of the net cash flow during year i , termed discounted cash flow, is,

$$DCF_i = \frac{NCF_i}{(1 + r)^i}$$

The sum total of all such discounted cash flows over the terms of the loan is the net present value, NPV of the loan:

$$NPV = \sum_{i=1}^n DCF_i = \sum_{i=1}^n \frac{NCF_i}{(1 + r)^i}$$

Since NPV is the sum of discounted outflows, the lower the NPV, the more attractive the loan. The annual discount rate, r , is termed the after-tax cost of capital for the enterprise.³⁸

For domestic corporations, the federal tax rate amounts to 48% on taxable income, if the taxable income is more than \$25,000 annually. A tax rate of,

$$T = 48 \text{ percent}$$

is assumed throughout this analysis.

For a small foundry, the cost of capital (this is the same as the return if funds are reinvested) before tax is estimated to be about 7%. After taxes, this figure reduces to about 3.5%. Therefore,

$$r = 3.5 \text{ percent}$$

3.2 Bank Financing

With respect to financing from conventional banking sources, two distinct possibilities need to be considered. One of these involves treating the pollution control equipment under consideration on exactly the same footing as any other item of capital equipment purchased by a foundry, and the second involves a special pollution control loan.

The availability and the terms of conventional bank financing are dependent upon the previous relationship between the lender bank and the borrower, the amount of risk involved from the lender's point of view, and the borrower's ability to provide adequate collateral against which the requested loan may be granted. Many small foundries may find it difficult to meet the collateral requirement because of their low asset base and a low-profit profile.

The term of such a source of funds is relatively short. The payback schedule typically consists of fixed amounts of money payable to the lender bank in monthly installments, consisting of the interest on the outstanding amount of loan and the principal payback, which reduces the loan outstanding for the following month. Because of this method of payback, the

actual, or effective interest rate is almost twice the nominal, or coupon rate. The coupon rate, being related to risk, itself is typically several percentage points above the prime rate. In the analysis that follows, the values ascribed to the parameters are:

term of Loan	36 months
coupon rate of interest	6%

This conventional bank financing operation described above in Section 3.1, has an NPV of \$102,015 for a principal amount of \$100,000.

3.2.1 Pollution Control Equipment Loan

Another more attractive possibility exists than conventional bank borrowing. Some, (though not all) banks are prepared to treat pollution control equipment on a different (more favorable) footing than other items of capital equipment for which financing may be sought. Such pollution loans have an effective interest rate 1% above current prime so that the rate fluctuates over the term of the loan as the prime rate moves. The period of the loan is also longer than with conventional bank borrowing. Whether the motivation for such preferential treatment stems from societal concerns or other reasons is beyond the scope of this report. If resort is made to such preferential treatment, the cost consequences are typically:

term of loan	5 years
annual interest rate	= 1 percent above prime rate
prime rate	= 6 percent (assumed to be constant during the term of the loan)

Present value analysis of annual interest or principal payback payments

through the full term of the above described loan yields a value of NPV of \$98,880 compared to \$102,015 for the conventional bank loan.

3.3 Financing Through Cash Flow

The foundry management may be able to install the pollution control system by financing through its cash balance. No outside loan is then needed to finance the investment, and the NPV of this option for the case considered, is equal to the cost of the system, which was assumed as \$100,000.

3.4 Governmental Aid to Financing

As a result of the effort to encourage industrial development in general, and in some cases, to encourage industry to install control equipment on sources of pollution, governmental aid is available in the following areas:

- a. Aids to individual borrowers for low-cost capital and
- b. Tax aids to industry through special regulations and procedures.

The consequences of the latter will be described in Section 3.5.

Many states now have financing programs for the purchase and installation of pollution control facilities. These states, via governmental and/or quasi-governmental agencies, assist in floating attractive low-interest bond issues and in raising the required funds through industrial mortgages. Such bonds bear a lower interest rate than any of the aforementioned methods, since the interest payments are presently free of federal and state income taxes. Table 3-A lists the various financing and tax aids available on a state-by-state

TABLE 3-A

FINANCIAL ASSISTANCE AND TAX INCENTIVES FOR INDUSTRY*

	State Sponsored Industrial 1 Development Authority	Privately Sponsored 2 Development Credit Corp.	State Authority or Agency 3 Revenue Bond Financing	City and/or County 4 Revenue Bond Financing	State Loans for 5 Equipment, Machinery	Excise Tax Exemption 6	Tax Exemption or Moratorium 7 On Land, Capital Improvements	Tax Exemption or Moratorium 8 On Equipment, Machinery	Sales/Use Tax Exemption 9 On New Equipment	Sales/Use Tax Exemption 10 Applicable to Lease of Pollution Control Facilities
Alabama	X	X		X		X	X	X	X	
Alaska	X	X	X	X	X	X	X	X	X	
Arizona	X			X						
Arkansas	X	X		X					X	
California		X							X	
Colorado		X		X						
Connecticut	X	X			X				X	
Delaware	X		X					X	X	
Florida	X	X		X						
Georgia			X	X					X	X
Hawaii				X	X	X		X	X	X
Idaho									X	
Illinois		X		X						
Indiana	X			X				X	X	
Iowa		X	X	X						
Kansas		X		X			X	X		
Kentucky	X	X		X	X		X	X	X	
Louisiana	X			X	X		X	X		
Maine	X	X		X					X	
Maryland	X	X		X			X	X	X	
Massachusetts	X	X		X				X		
Michigan				X				X	X	X
Minnesota		X	X	X	X		X	X		
Mississippi	X	X		X			X	X		
Missouri		X		X			X	X	X	

*Condensed from Reference 43

TABLE 3-A (cont'd)

	1 State Sponsored Industrial Development Authority	2 Privately Sponsored Development Credit Corp.	3 State Authority or Agency Revenue Bond Financing	4 City and/or County Revenue Bond Financing	5 State Loans For Equipment, Machinery	6 Excise Tax Exemption	7 Tax Exemption or Moratorium On Land, Capital Improvements	8 Tax Exemption or Moratorium On Equipment, Machinery	9 Sales/Use Tax Exemption On New Equipment	10 Sales/Use Tax Exemption Applicable to Lease of Pollution Control Facilities
Montana		X		X			X	X		
Nebraska	X	X		X						
Nevada				X						
New Hampshire	X	X	X						X	
New Jersey	X	X								X
New Mexico				X		X				
New York	X	X	X	X	X		X	X	X	X
North Carolina		X		X					X	
North Dakota	X	X	X	X		X	X	X		
Ohio	X	X	X	X					X	X
Oklahoma	X		X	X	X				X	
Oregon		X	X				X			
Pennsylvania	X	X	X	X		X		X	X	X
Rhode Island	X	X	X	X			X	X		X
South Carolina	X	X		X			X	X	X	
South Dakota				X		X				
Tennessee		X		X						
Texas	X			X			X	X		X
Utah	X	X	X	X						
Vermont	X	X	X	X						X
Virginia	X	X		X					X	
Washington		X		X						
West Virginia	X	X		X	X	X			X	
Wisconsin				X					X	
Wyoming		X	X	X		X				

basis.

For example, in Pennsylvania, the Pennsylvania Industrial Development Authority (established through the Pennsylvania Industrial Development Authority Act of 1956) through county industrial development authorities, is authorized to issue revenue bonds after the borrower has established his own credit and obtained an underwriter. The Authority collects and dispenses coupon and sinking fund payments, through a lease arrangement. There are certain fixed costs incurred in floating a public bond issue, and, therefore, this method becomes more attractive with increasing amounts of capital required. If it is decided to raise money through such a vehicle, the consequences to the cash flow are analyzed below. There are several simplifying assumptions made regarding the various parameters of this alternative:

amount of capital raised	\$100,000
term of bond	20 years
coupon rate	5%
fixed issue costs	\$50,000

The retirement of the bond can be designed in one of several ways. One way is to retire the total amount at end of the term. Alternately, a sinking fund may be provided for serial retirement of a part of the debt principal throughout the term of the bond with a sizeable amount (balloon) to be retired at the end of the term. The particular way of retirement is not materially significant in a net present value analysis but is very important in the cash flow analysis to be discussed later in this section. A present-value calculation as outlined above in Section 3.1.3 for this alternative (assessing fixed

issue costs in the first year) yields a value of

$$NPV = \$110,590$$

It would be extremely rare to obtain a bond issue of only \$100,000. Even if it were possible, the advantages of lower interest rate and longer debt term are reduced to a great extent by the fixed costs of raising the capital. A way of reducing the effect of fixed costs is to increase the amount to be borrowed. This may be done by a single company by grouping a number of projects that require capital, the upper limit being the ability of the offering to attract capital investors. For the small foundry, however, such a possibility is remote.

If a number of foundries grouped together for such financial purposes, then the bond issue would appear as an attractive alternate, since the fixed costs are then prorated over a larger offering. (In Pennsylvania, the availability of industrial mortgages²⁴ and certain lease-amortization options through the Pennsylvania Industrial Development Authority makes this alternate less attractive. This mortgage provision is peculiar to Pennsylvania). The organizational and management aspects of the formation and the functioning of such a group are discussed in detail in Section 5, and special problems arising from this situation are described in Section 6. For the purpose of this analysis, the following situation is assumed:

no. of foundries in group	10
individual capital requirement	\$100,000
total capital requirement	\$1,000,000
fixed costs	\$50,000

The cash flow calculations, and the subsequent net present value analysis performed on this alternative yields a value of,

$$NPV = \$89,720$$

Figure 3-1 shows the present values of net cash outflow for the various alternatives studied above:

- (1) Conventional Bank Financing
- (2) Special Pollution Control Equipment Financing
- (3) Financing From Cash Flow
- (4) Bond Issue - Individual
- (5) Bond Issue - Group

The profit goal of a foundry in respect to financing costs, is to minimize Net Present Value. The Net Present Value associated with alternative 5 is the smallest; the largest value is obtained for alternative 4. Both alternatives 2 and 5 yield NPV's smaller than \$100,000: a significant finding, in that these two borrowing alternatives are better than the alternative of paying from the foundry's own cash source. Figure 3-2 shows these effects in a different way by indicating the excess cost of financing by other methods over the group bond issue alternative.

The advantage gained in mortgage financing, available in Pennsylvania, is similar to that obtained with alternative 5 above.

3.5 Special Tax Considerations

The discussion heretofore concerned itself with the various ways of

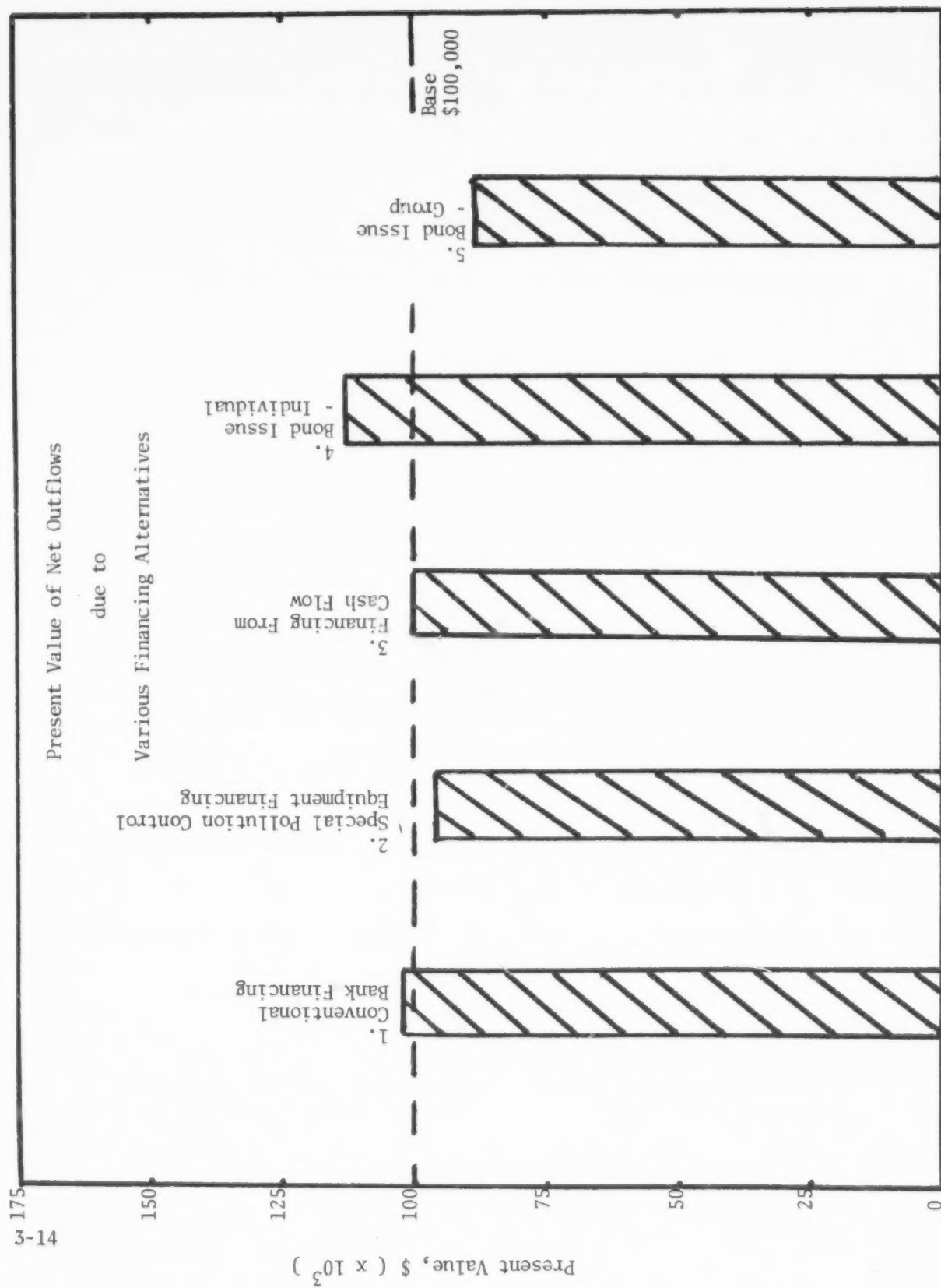


Figure 3-1

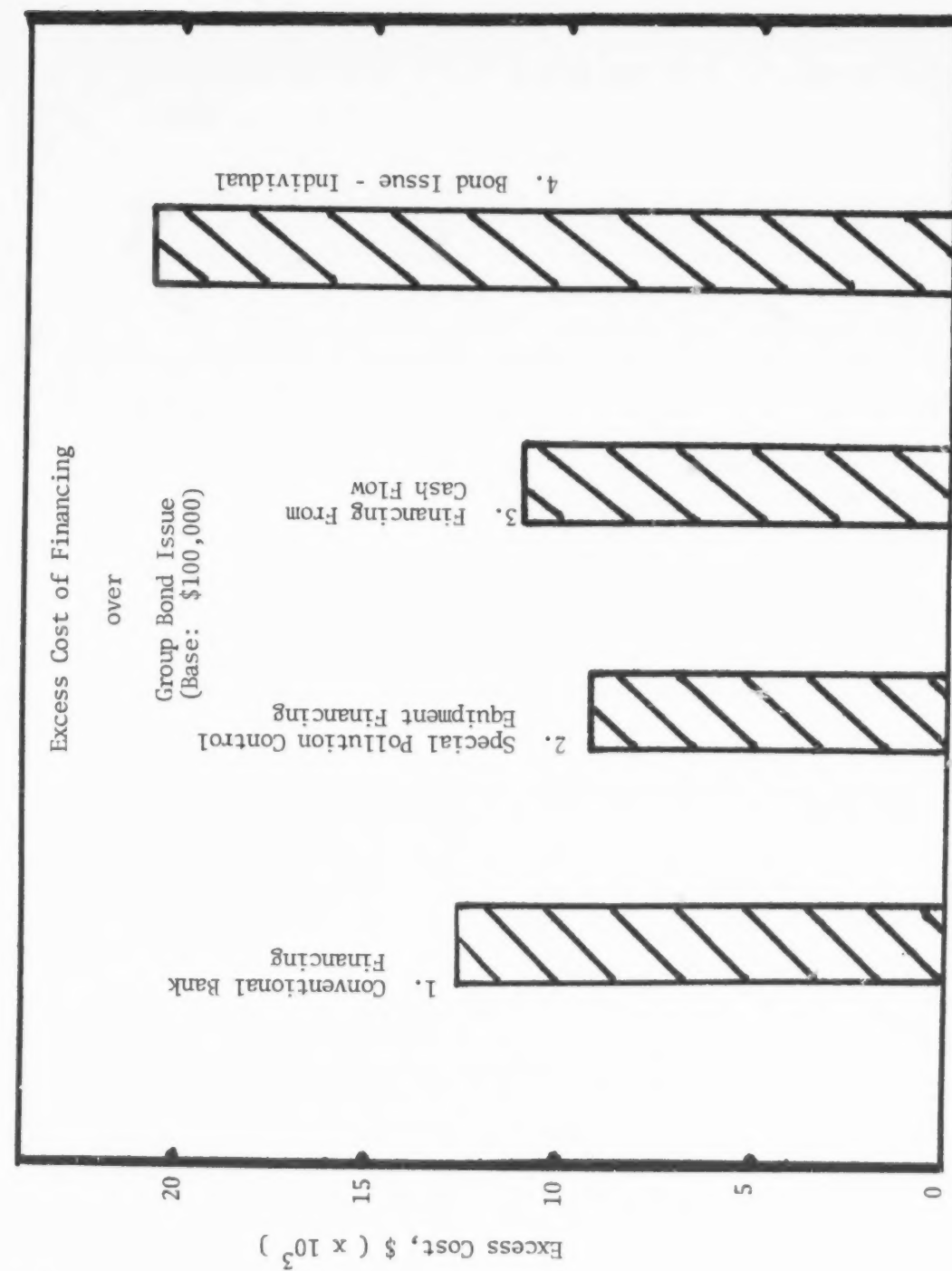


Figure 3-2

raising the required funds. Additional advantage will be gained by considering the tax aspects of the situation.

3.5.1 State and Local Tax Incentives

Because of the nature of pollution control equipment, many state and local governments give preference to the equipment buyer in terms of sales, excise and other taxes (Table 3-A). The amount of money saved through these tax incentives is not material, compared to the tax-depreciation savings (below, Section 3.5.2) and the nature of such preferences varies geographically. They will not be described in detail here.

3.5.2 Rapid Amortization and Investment Credit

There are many methods available for depreciating a capital equipment. Before use is made of the depreciation alternatives in the present analysis, it is necessary to trace the effect of depreciation on tax liability, net profits after taxes, and cash flow.

The net annual income before taxes, p , may be written as

$$p = Q - D$$

where,

Q = operating income

and,

D = allowance for depreciation during the year.

Therefore,

$$\begin{aligned} p &= p (1 - T) & L &= p T \\ &= (Q - D) (1 - T) & &= (Q - D) T \\ &= Q (1 - T) - D (1 - T) & &= Q T - D T \end{aligned}$$

The allowance for depreciation, like the interest expense, reduces the net profit after tax as well as the tax liability. But unlike the interest expense, depreciation allowance does not represent an outflow of cash. Thus, the effect of depreciation on cash flow is through the reduced tax liability (tax savings), and represents a net inflow:

$$NCF = D T$$

An analysis of this net cash flow through the depreciable life of the equipment will yield a net present value:

$$\begin{aligned} NPV &= \sum_{i=1}^k DCF_i \\ DCF_i &= \frac{NCF_i}{(1 + r)^i} & i &= 1, 2, \dots, k \end{aligned}$$

where k is the depreciable life of the equipment. The rest of the symbols have same meanings as in Sections 3.1.1 and 3.1.2.

Rapid Amortization

The Tax Reform Act of 1969 provides for rapid amortization of certified pollution control facilities over a 60-month period, irrespective

of the guideline useful life of the equipment. This amortization is available under certain conditions outlined in Article 169 of the Internal Revenue Code. The accelerated writeoff was provided to encourage capital investment in pollution control.

Investment Credit

The other method of depreciation considered here is the double-declining balance method, taken with the investment credit. The double-declining balance is the quickest allowable way, except for the aforementioned special rapid amortization, of depreciating equipment through its useful life. The job development investment credit is now available under conditions described in the Tax Reform Act of 1971. The effect of this investment credit is to permanently reduce the tax liability by an amount equal to 7 percent of the initial cost of any capital equipment, generally during the year the equipment is bought. The effect of the tax credit during the year it is applied is to increase the net cash inflow by that amount.

A schedule of annual allowances for depreciation for each of the above methods must be developed after taking into consideration the numerous rules and regulations under the applicable tax laws. From this can be developed the DCF's and then the net present value as described above.

A foundry must choose one or the other of the above tax benefits. It cannot use both the rapid amortization and the investment credit.

Since the investment credit and rapid amortization are mutually exclusive and can have significant profit and cash flow implications, a foundry must exercise considerable prudence in making this selection. It will generally turn out to be financially more beneficial to use the invest-

ment credit (coupled with ordinary double-declining balance) rather than the special rapid amortization method for pollution control facilities. This preference is accentuated first by the fact that process changes made to comply with pollution control regulations do not meet requirements for rapid amortization (only control devices do), and secondly, by the fact that the investment credit, per se, never needs to be repaid, whereas rapid amortization really represents only a postponement of taxes. The preference becomes irresistible for industry segments in which the normal depreciable life of equipment is not much in excess of the 5-year period specified for rapid amortization of pollution control facilities.

3.6 Effective Cost of Equipment

Because of their additive nature, the two cash flows, one based on financing costs, and the other based on tax strategy, may be combined to study the overall effect of pollution control equipment investment. It should be noted that the financing costs result in net outflows and the depreciation in net inflows. The net of these two flows is the effective cost of the pollution control equipment to the foundry. Figure 3-3 shows this effective cost for combinations of the five financing alternatives discussed previously with each of the two depreciation methods. The investment credit - double-declining balance option gives slightly lower costs for all five alternatives. Again, the group bond issue is the least-cost alternative.

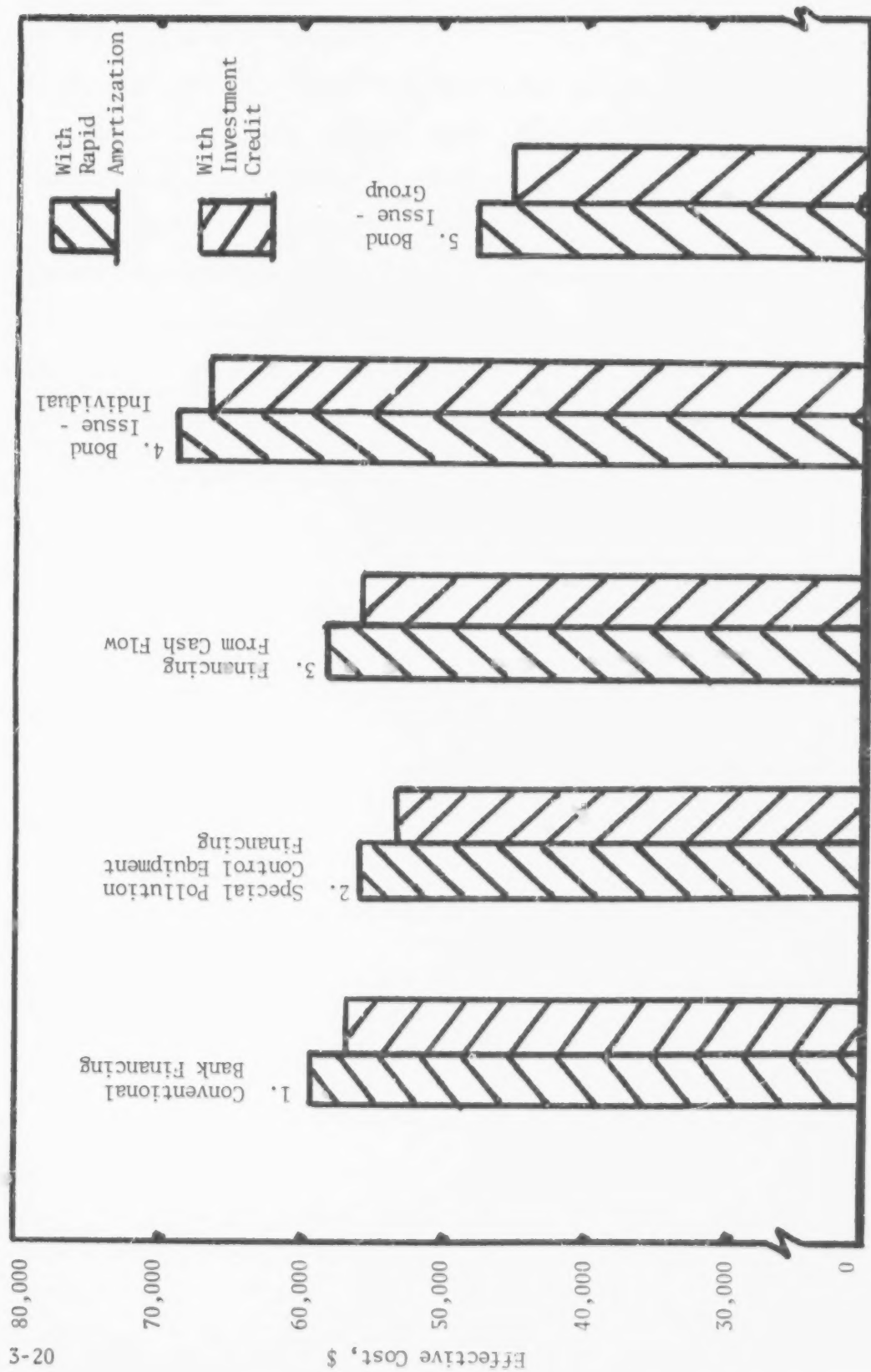


Figure 3-3
Effective Cost of Pollution Control Equipment
From Various Financing and Tax Alternatives

3.7 Cash Deficit Considerations

If liquidity of a foundry operation is critical, then to the above analysis of financing and tax considerations from the effective cost point of view should be added a study of the expected amounts of yearly funds surplus (net cash inflow) or deficits (net cash outflow) for the instances cited. These funds, surplus/deficits, must not be reduced to their present value, because they represent actual excess or needed funds during a particular year.

Figure 3-4 shows the funds surplus/deficit situation for the years after acquisition of the control equipment for the following financing alternatives:

1. conventional bank financing
2. special pollution control financing
3. bond issue - group

The yearly funds deficit with alternative 1 is between \$25,000 and \$34,000 during the term of the loan. For the remaining useful life of the equipment it yields a funds surplus, regardless of the method of depreciation. Similarly, the funds deficit with the special pollution control financing varies between \$10,000 and \$18,000 during the first five years. For the group bond issue, there is a deficit, during year 20, of \$102,000. This is so because of the retirement of the bond in a large balloon at the end of its term. Other methods of retirement will affect the surplus/deficit picture differently.

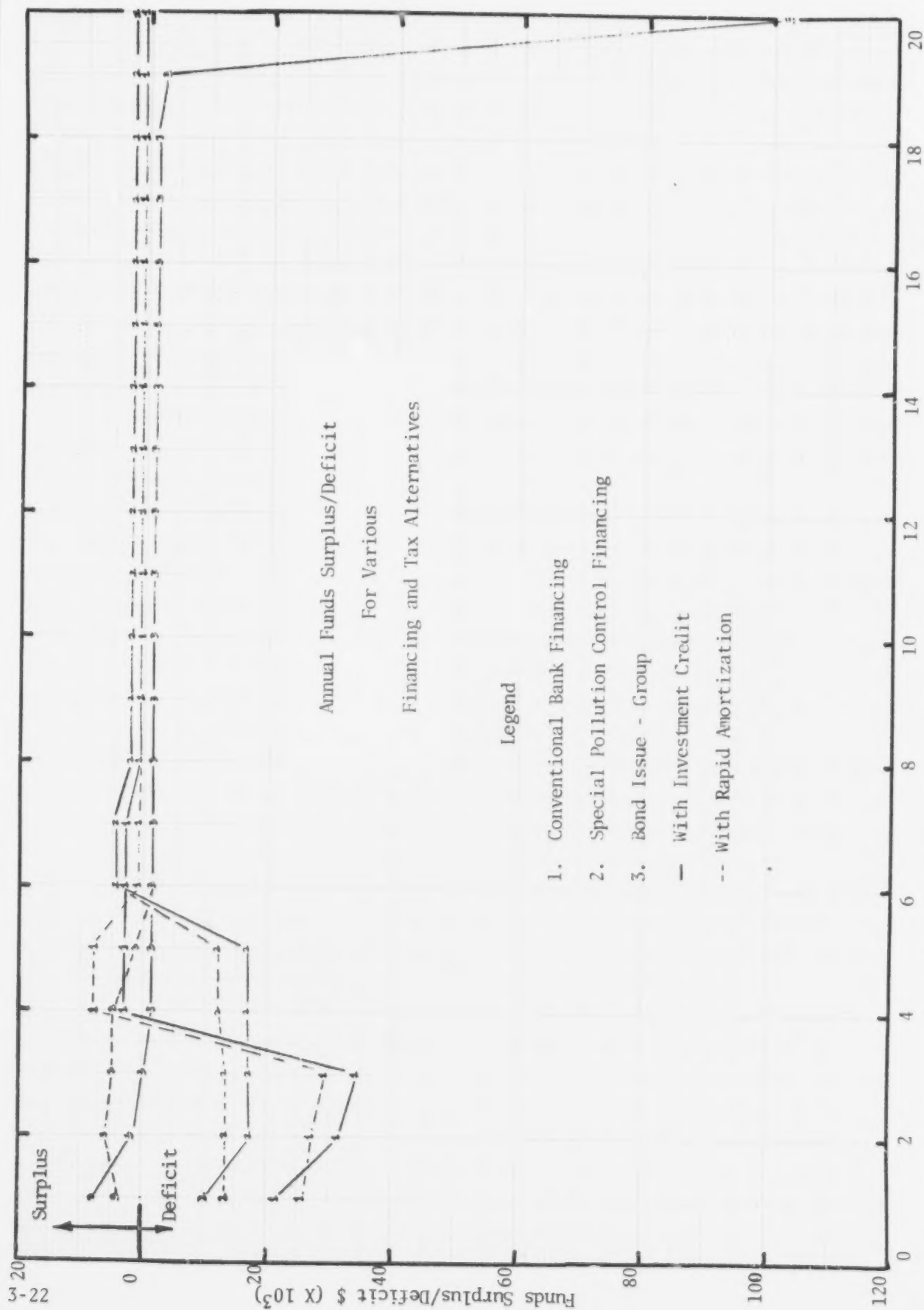


Figure 3-4

3.8 Effect of Initial Cost on the Financing Alternatives

In the discussion above, the typical initial cost of pollution control to a small foundry was taken as \$100,000. The analysis showed the advantages of the small foundries grouping together for the purpose of raising capital, in that the financing costs were significantly lower than for other borrowing alternatives.

Other considerations outlined in Section 4 will tend to reduce the initial cost of control equipment to a considerable extent, for a group-buying venture. In order to study the effect of such a reduction in the initial cost on the relative attractiveness of the various financing methods, the above net present value analysis was repeated for initial costs of \$85,000, \$70,000 and \$55,000. The effective costs of equipment, for the various financing alternatives, and for different initial costs are shown in Figure 3-5. The relative rating of the financing alternatives on the basis of the effective cost remains unchanged for a variation in initial cost from \$100,000 to \$55,000. The advantage of group-financing is thus maintained even with lower initial costs.

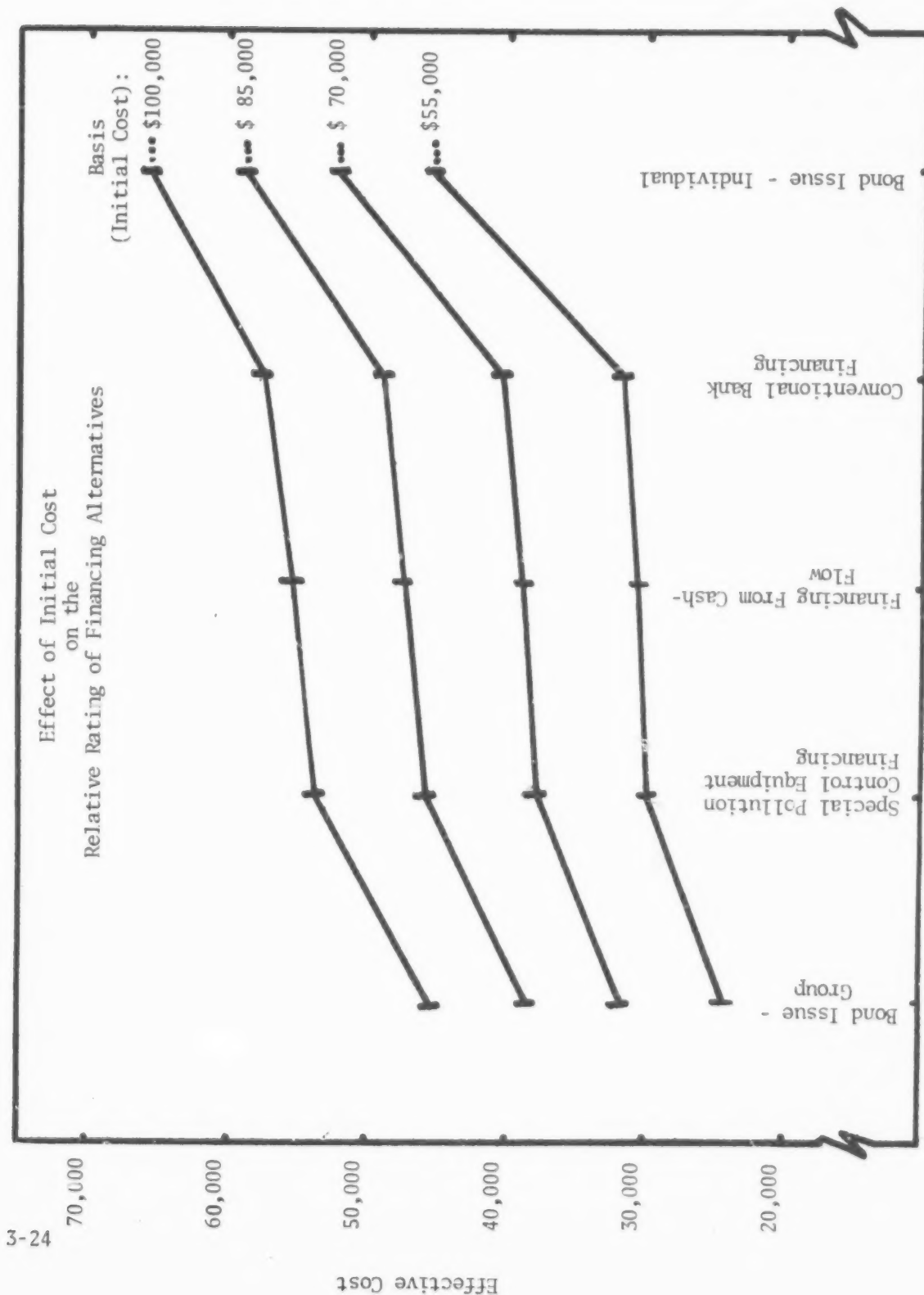


Figure 3-5

4. Effect of Group Action

4.1 Identification of Appropriate Group(s)

Thus far, the report has discussed the compliance alternatives, regulations, variability of costs with process and equipment parameters, and the variability of costs with financing alternatives. These are all a prelude to the identification of groups, and an evaluation of savings which could result from group action. This section deals with methods of identifying group members and estimates savings which could ensue from group action. Two things are essential to the formation of economically effective plant groupings.

- (1) The schedule for taking procurement and financing action by individual plants must be within fairly close time limits.
- (2) Individual members expenses for equipment and/or financing must be significantly less as group members than that of individual action.

If process changes or the addition of control devices were to be effected as normal capital equipment additions, it would be extremely difficult to find companies whose individual schedules correlated sufficiently to obtain economies of scale in procurement and financing. This is of course due to the variation in end date by which the capital equipment action is to be taken. When air pollution regulations are to be met, however, an irrefutable requirement both in need and time is often present, so that sufficiently high schedule correlation is readily available.

For example, a random sampling of compliance order deadlines for installation of abatement devices in Pennsylvania foundries showed the following end dates for 29 foundries:

Table 4-A

COMPLIANCE ORDER DEADLINES

<u>Dates</u>	<u># of Foundries</u>	
Feb. 1972	1	
April 1972	1	
July 1972	1	
Sept. 1972	3	Group 1
Oct. 1972	1	
Nov. 1972	3	
Dec. 1972	5	Group 2
Jan. 1973	2	
Feb. 1973	10	
April 1973	1	Possible Additions
June 1973	1	to Group 2

From a scheduling point of view it would be possible to make two time-correlated groups, and perhaps add the April and June 1973 plants to the second group. The time decorrelation which has heretofore largely frustrated group use of economies of scale approaches to capital equipment acquisition will probably not be a significant deterrent in air pollution control devices.

The second requirement is more difficult and troublesome, in that it is more technically involved, and the whole trade-off analysis that needs to be applied is steeped in mythology and hindered by a great paucity of information.

This study has approached the problem by a sort of technical ecumenical method in that it searched for overlying commonalities of plant operation and device design, instead of focusing on difference. It is undoubtedly true that no two foundries are exactly alike. They have different buildings, products, metallurgy, management, equipment, composition and cleanliness of scrap, varying coke ratios, etc., in an endless list. Despite these differences from plant to plant, control devices for foundries are bought and installed with apparent success. The study was interested in how this was accomplished as a clue to commonalities involved.

Particle size distributions as indicated in Section 2 have pronounced effects on control equipment performance and cost. A recent comprehensive report ² in this field states, "Of particular importance in any stack sampling method is determination of emission particle size since these data will largely determine overall collection efficiency of a control equipment system." Later on, the same report states that foundries do not care to pay for stack sampling to determine particulate concentrations and further that, "equipment manufacturers do not, as a rule, require cupola emission levels when quoting control systems. Equipment designs are generally based on years of experience and rules of thumb, with design contingencies usually large enough to cover variations in type and quantity of emissions from one installation to the next."

Our discussions with eight control device manufacturers and a score of small foundry owners supports this finding. Emission inventory returns in the State of Pennsylvania also show this to be the case, since foundries very seldom note stack measurements as the basis of their statements on emissions

on the inventory forms. In larger foundries, and this is also true for most large industrial plants, device manufacturers may make tests if they are relatively sure of a large order, or the plant may make such tests when their cost is a very small fraction of the total job.

What this means is that the control device part of the system is not designed to painstakingly meet a specific grain loading or particle size distribution at a specific cupola because such data are not available. Instead, a series of designs are employed in an application type engineering approach, where any one design can cover a fairly broad requirement in input loading, particle size distribution and gas volume determined by other than direct stack requirements. This also indicates that it may be possible to group plants with close enough requirements to fall within a design integer.

Of basic importance in making first-cut plant groupings is the necessity of grouping plants by common regulation. Section 1.4 of this report dealt with applicable laws and regulations, and indicated the diverse regulations presently in existence within the State of Pennsylvania. These differences would have reduced the number of prospective plant groups that would have common regulations, and which then would be further examined to determine if other operational commonalities existed. Under the proposed Pennsylvania regulations to be submitted to the federal government by the end of January, 1972, as part of Pennsylvania's implementation plan, a unified regulation is proposed as explained previously in Section 1.5.3.

This unified regulation, if finally enacted, will greatly reduce the problem encountered by way of varying regulations with the state. For particulate emissions from foundries one need only use the equation:

$$A = 0.76E^{0.42}$$

where A is the allowable emission in tons per hour, and E is the emission index in lbs. per hour, obtained by multiplying the melting capacity of a foundry in tons per hour by a source factor of 30 lbs/ton of melt. For convenience, this equation was shown in graphical form as Figure 1-5.

The first piece of information necessary then is the melt capacity of the foundry, since this has a direct and well-defined relationship to the allowable emissions. A typical grouping for small foundries might be

Table 4-B

<u>Melt Rate Grouping</u> <u>TPH Melt</u>	<u>Allowable Emissions lbs/hr</u> <u>per Pa. Proposed Plan</u>	<u>% Foundries This Size</u> <u>In Study Area</u>
1-2	3 to 4	8
3-4	5 to 5.8	35
5-7	6.4 to 7.2	31
8-10	7.6 to 8.4	12

Once the tentative groupings by regulations have been made, the next step is to examine commonalities of importance in control equipment design.

Gas Volume

Gas volume has a direct influence on design, and is one of the basic determinants of acquisition and operating costs. It is therefore important in determining groupings to know the stack gas volume and its temperature.

Stack gas volume is essentially dependent on three parameters: the blast air, the air infiltrated through the cupola door, and the products of combustion which are related to blast air and properties of the charge.

Two attempts were made to analyze data which would relate melt rate to blast rate, so that one could use melt rate data readily available on Pennsylvania Emission Inventory forms to quickly obtain blast volume. The result of this analysis is shown in Figures 4-1a and 4-2a. The correlation coefficient for the total points is good at 0.79 for the Kearny data, and 0.886 for the Polycon data; however, the correlation in the area of interest (small foundries with a melt rate of less than 10 tons/hr.) is poor at 0.291 and 0.459, respectively, as shown in Figure 4-3a. Therefore, it is not possible to go directly from a Pennsylvania Emission inventory form to a gas volume determination.

Another approach is to simply use Table 2-1 of Reference 5, entitled, "Range of Sizes and Operating Recommendations for Conventional Cupolas," which lists suggested blower size as a function of cupola size or area inside of lining. A third approach is to obtain existing data on fan performance or actually measure the load to the charging fan and from the fan performance curve determine the cfm performance.

The infiltrated air velocity through the stack door is normally taken at 300 ft/min. The products of combustion can add about another 15% to the blast air. Thus, by knowing only the blast rate and charge door size, one can approximate the total volume of stack gas by adding the three contributions. The volume for a number 7 cupola capable of melting nine tons per hour would be:

Air through tuyeres (blast air)	5,200 scfm
Infiltrated air through door of 25 sq. ft. (300 ft/min)	7,500 scfm
Products of Combustions (15% blast air)	<u>780</u> scfm
	13,480 scfm

At a typical stack exit temperature of 1,600°F, the exit volume is 52,383 acfm.

Stack Gas Exit Temperature

The stack gas exit temperature can be obtained relatively simply by direct temperature measurements, or by heat balance calculations. Stack temperatures depend on operating temperatures which range between 2,600 and 2,800°F (depending on iron-carbon ratio and amount of blast air), and the height, diameter, and type of lining of the stack.

If we permit a 23% variation in blast air for variations in metallurgical heat requirements, this would change the output volume by +4,660 acfm or a change of +8%, probably well within any design tolerance used by a manufacturer. That is to say, if the nominal design point for gas handling capacity was 52,383 acfm @1,600°F, the capacity of the takeoff ducting before

the 1st quench would probably be 60,000 acfm @ 1600°F. In most instances, the gas would be cooled by quenching in gas conditioning equipment before entering any type collector so that the factor having the largest effect on cost is the gas temperature upon entering the control device, with differences in quench entrance temperature of secondary importance.

In attempting to develop commonalities on the basis of stack gas volumes the largest source of variation is in the charging door size. In the example noted, 56% of the stack gas volume came from infiltrated air. Not only is this a large contributor, but the door size varied from plant to plant in the visits made.

This study is concerned with dispersed small foundries, and in the conduct of the study seven of these were visited. Of these seven, five used cupolas, all with hand charging operations. The charge was placed in the cupola either by dumping directly from wheelbarrows, or by hand or fork feeding. Some of the charging doors on these operations were obviously much larger than necessary to accomodate any reasonable size scrap entrance - much larger than any scrap which was seen being loaded. There is no operational limiting factor except size of scrap in the charge which would preclude reducing the size of the charging door in such hand-charged installations.

In larger capacity plants, skiphoists and conveyors may be used where restricting the door size could cause problems which might be expensive to overcome. Where charging buckets are used, equipment change will definitely be required since these buckets require large charging doors to operate. The main metallurgical draw-back from restricting the door size brought up in plant discussions with foundry operators is the possibility that the small

opening may not permit a homogeneous charge distribution. For hand operations a readily movable chute could overcome this defect. A recent study² reports that evidence from companies using mechanical feeders with restricted cupola doors shows no adverse effects due to charge distribution or segregation.

If there are no metallurgical problems, especially as it appears for the smaller foundry using hand-fired means, then cost savings to be found in control device acquisition and operation are a compelling factor for decreasing the charge door size.

Quantity of Emissions

Two factors have a strong effect on emission quantities. These are specific blast rate and iron-carbon ratio (coke rate) employed as cupola operating variables. Correlation studies² have shown that for unlined cupolas the particulate emissions to iron-carbon correlation coefficient is 0.703, and for specific blast rate, 0.600. These coefficients, part of a correlation matrix, can be used to express emission quantity as follows:

$$E = 57 - 6.6C + 0.1B,$$

with E = lbs.-per-ton of melt, B = specific blast rate, and C = the iron-carbon ratio.

Referring to our earlier example for a number 7 cupola, the emissions-per-ton of melt by applying this formula would be:

$$E = 57 - 6.6 \times 8 + 0.1 \times 327$$

$$E = 37 \text{ lbs/ton}$$

This quantity of emissions per ton of melt is substantially higher than factors mentioned by Duprey¹⁷ and Chass, Lunde¹⁸ et al.

Use of this formula may therefore result in control equipment designs with an already built-in safety factor.

Much has been said and written about the likely effect of various scrap mixes, their cleanliness, state of corrosion and amount of contamination or alloying materials on the amount of emissions. To the authors' knowledge there is no source of data showing consistent quantitative effects of scrap composition and condition versus emission levels.

Even if it were possible to predict a characteristic, for example, the contribution of iron oxide to the emissions as a function of oxide on the scrap surface, it would be difficult for any operator to specify and maintain quality control over incoming scrap and scrap storage to the extent necessary to remain in reasonably tight pre-set limitations. A basic notion is that the cleaner and less contaminated the scrap the less emissions, but accurate analytical relationships are not available.

Thus in the case of total emissions, the formula noted above, or some rule of thumb is employed with an equipment designed for the worst case within a given range.

Particle Size Distribution

In many control equipment designs this ranks as one of the most important design characteristics. As an example, performance of a wet scrubber is related to particle size on the following basis:

$$E = 1 - e^{-Z}$$

where

$$Z = K L \sqrt{\frac{v_t D_p^2 \rho_p}{18 D_w \mu}}$$

and in which E = performance efficiency

K = correlation coefficient

L = liquid injection rate

v_t = throat velocity

D_p = particle diameter

D_w = droplet diameter

ρ_p = particle density

μ = gas viscosity

As the diameter of the entrained particle decreases, the efficiency decreases in exponential fashion. Since particle density, gas viscosity (except for gas conditioning equipment), and particle size are not within the control equipment designers control, his design can only vary throat velocity, liquid rate, and droplet size. Actually droplet size is related to both liquid rate and throat velocity in the fashion:

$$D_w = \frac{1.6 \times 10^4}{v_t} + 28.5 L^{1.5}$$

so that the only two design variables affecting efficiency for a given gas volume are:

1. liquid rate
2. throat velocity

Higher velocities are obtained by narrowing the venturi and by increasing the fan power to force or draw the gas through at the desired velocity. Energy consumption by the fan represents a large portion of operating costs as can be seen by reference to Figures 4-4, 4-5, showing increases in both acquisition and operating costs for obtaining higher efficiency with a foundry wet scrubber at constant gas volume and constant input grain loading.

On fabric filters grain loading and gas volumes have more pronounced effects on design since the design technique is to maintain a certain air-to-cloth ratio for a specific type industry. For example, 6.5 is the ratio commonly used on asphalt batching plants. The collection efficiency for a given fabric is high over practically all particle size ranges, so for foundries particle size consideration is not of practical importance. An important trade-off design would be the amount of gas conditioning to reduce gas volume versus baghouse savings.

Electrostatic precipitators are critically dependent on electrical characteristics of the particles and the gas volume, and have high fixed costs placing most foundries outside of effective utilization because of low gas volume and hence high cost per cfm handled.

Since improvements in control efficiencies in most cases involve capture of the smaller particles (less than 10 microns) and stack tests are only infrequently performed, one might properly question how particle size data is obtained. There is a paucity of published literature, and that available indicates wide swings in sizing as can be seen from reference to Table 4-Ca.

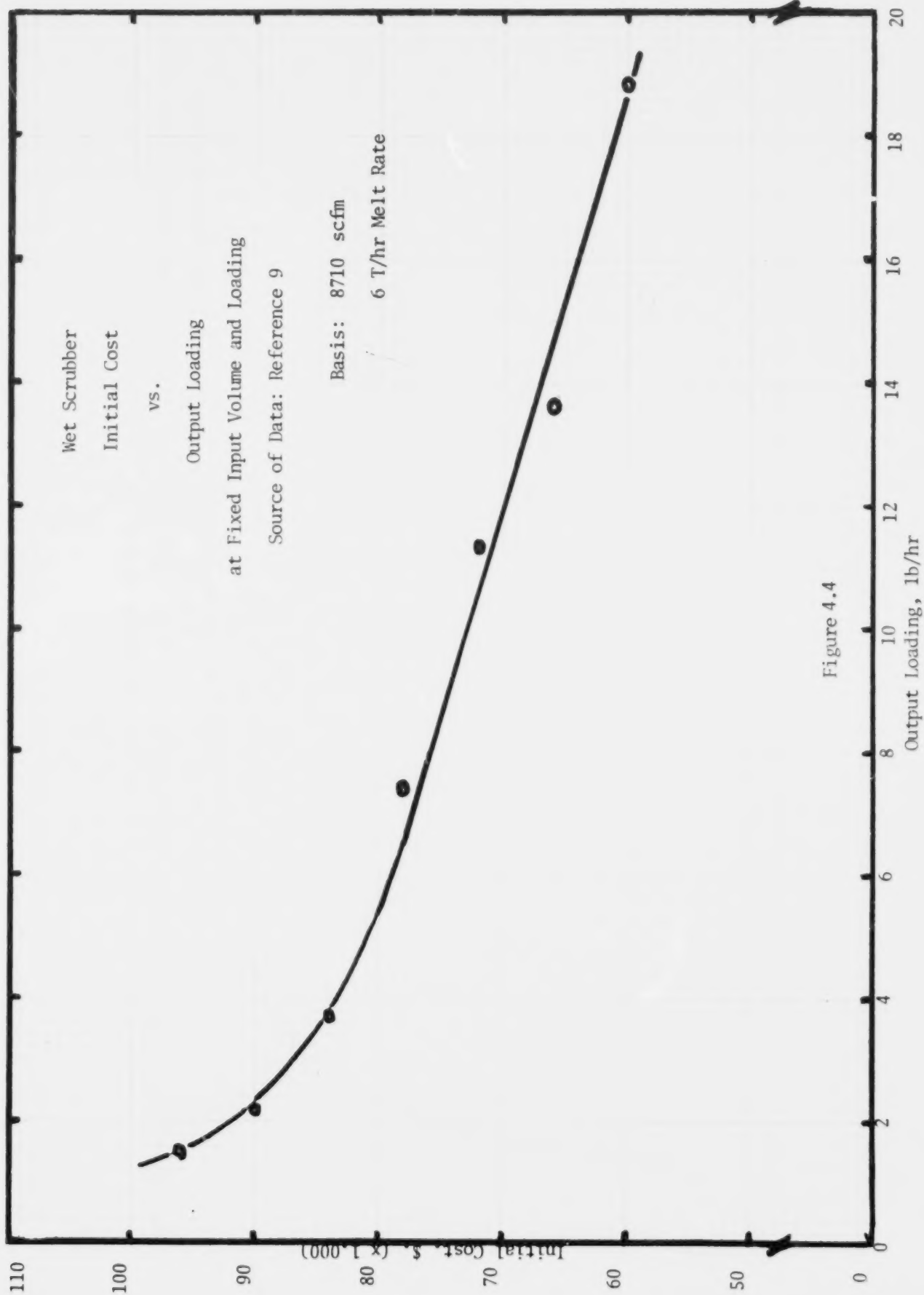
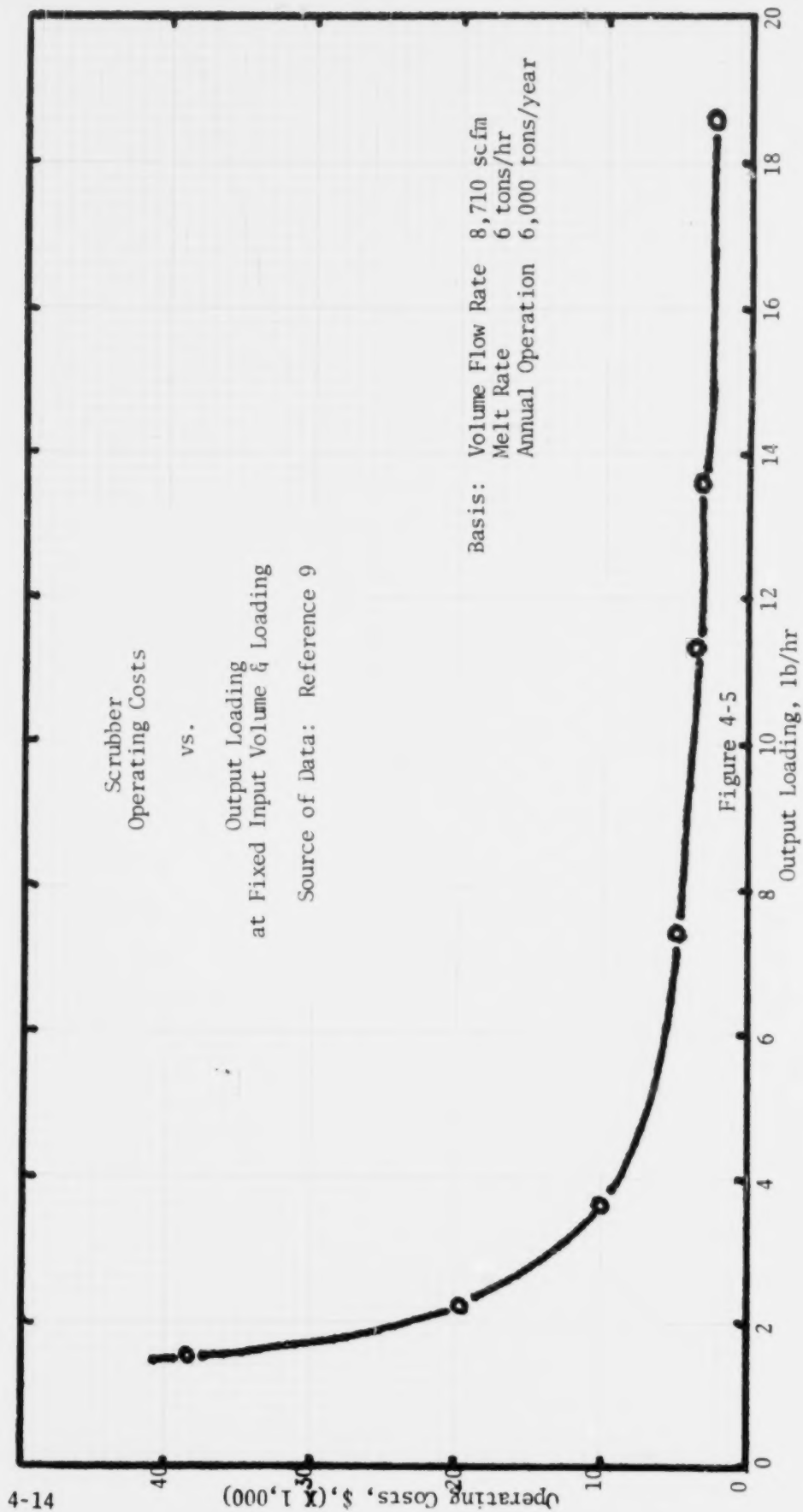


Figure 4.4



One can expect differences in particle sizes even at the same plant taken at the same time if different sampling methods are used. Furthermore, size analysis by the use of cascade impactors may differ markedly from optical or settling measurements. The former measure by sorting on the basic particle dynamic characteristics while the latter are more closely true dimensional measurements.

Some generalization may be possible in that particles greater than 44 microns probably occur from dirty scrap and coke breeze while particles less than five microns in size are probably due to metallic oxides. Since any collector contemplated for application in a foundry would essentially have 100% efficiency for particles over 44 microns in diameter, dirty scrap and coke breeze are not limiting performance variables.

Operating Variables vs. Cupola Design Variables

Thus far the discussion has centered on operating variables such as blast air rate, iron to carbon ratio, melt rate, and blast air temperature. There are in addition to these operating variables, cupola design variables, such as lined or unlined, type of lining, blast air heating, gas takeoff, oxygen enrichment, fuel injection, etc. The most extensive study conducted to date² on this subject could not find any significant effect on cupola emission rates from any of the cupola design variables used in this country.

Based on the foregoing, it appears that foundries can be grouped in relation to a common series of control devices depending on only several operational conditions, namely, blast volume, door size and stack exit temperature. There are, however, other parts of the total systems package which only

in rare situations will be amenable to common solutions. These factors have to do with the installation of the control device and its inter-connection with the present process plant. Figure 4-6 is a schematic of a wet scrubber-cupola and indicates what portion of the equipment could be common, and what parts custom.

Part 1, the cupola cap, could be common on the basis of stack diameter.

Part 2, the connecting ductwork to the gas conditioner, will be unique.

Part 3 is the gas conditioner which is common to a given gas flow and temperature.

Part 4 is the scrubber, and is common for a given gas volume.

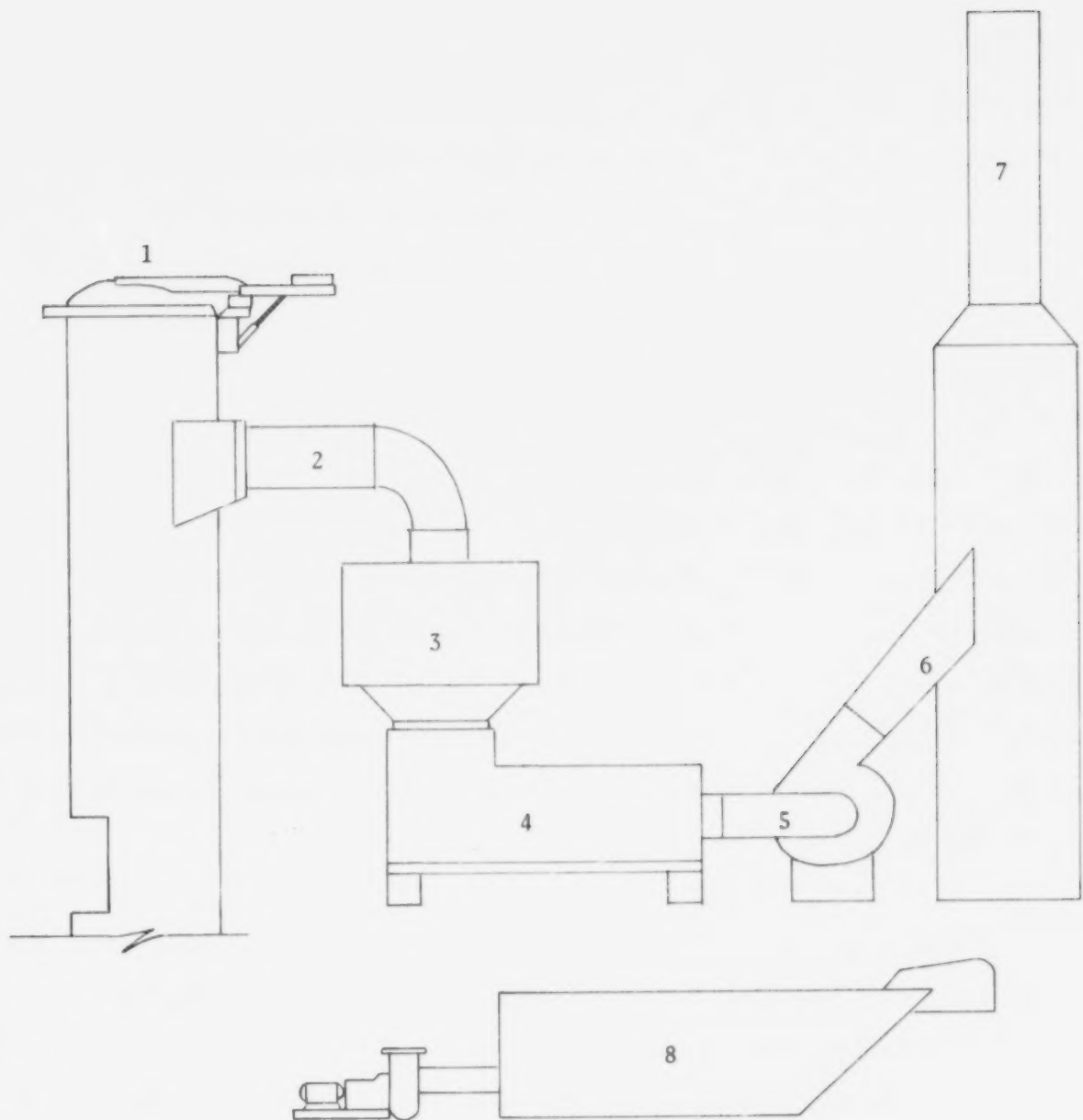
Part 5 is the fan, common for a given gas volume, and pressure drop.

Part 6 is the inter-connection to the exit stack which is unique.

Part 7 is the exit stack which is common.

Part 8 is the water storage-clarification system, common for liquid flow rates and grain loadings.

Interconnections can be quite unique, piercing roofs and walls, and sometimes utilizing present unused cupolas as part of the system and sometimes resulting in a single gas conditioning and control device to serve two or more operating cupolas. Location of electric, water and sewage lines can have a sizeable effect on complete, installed, system costs. Mounting of the system



Wet Scrubber - Cupola Schematic

Figure 4-6

with different interconnecting runs and clearances also make every job in totality a unique one. Most of the unique features have to do with placement and installation, while economies of scale may be available by concentrating on the gas conditioning and cleaning portion of the system.

In establishing common groupings related to the gas conditioning and cleaning device portions, omitting placement and installation, the approach as shown diagrammatically in Figure 4-7 could be employed.

The foundries are first grouped within a reasonable geographic region to facilitate communications and hold inter-plant travel costs to a minimum. In Pennsylvania, for example, the whole state could constitute the geographical region or perhaps the western part of the state with portions of Ohio, while the eastern portion could also include parts of contiguous states. The regional selections must balance economies of travel and communication with total foundry population in the area, and the regulations governing in the region.

The common regulations area screening is shown as a two-way process with regional screening because it affects regional choice. Fortunately, the effect will be dramatically reduced with statewide emission regulations aimed at meeting national ambient standards.

The necessity for all group candidates to have roughly the same schedule was noted in the early part of this section. This constitutes the next level of screening.

COMMON GROUP SCREENING PROCESS

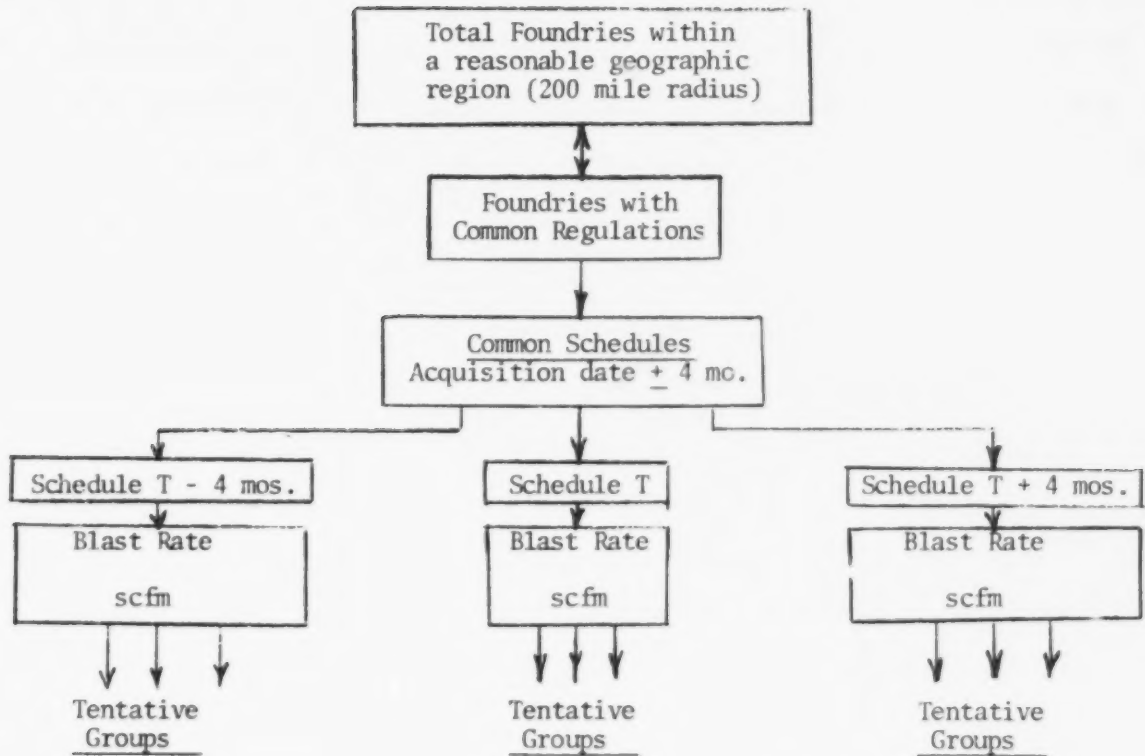


Figure 4-7

It has been noted that measureable characteristics of the foundry effluent have little to do with cupola design, according to the most detailed information to date. It has also been noted that the most highly correlated data relating operating variables to quantity of emissions is represented by:

$$E = 57 - 6.6C + 0.1B$$

with E = lbs.-per-ton of melt, B = specific blast rate, and C = the iron carbon ratio. In addition, a correlation coefficient of 0.79 relates blast volume to melt rate for all foundries that were studied. The greatest variant in gas volume is the infiltrated air through the cupola charging door, and further that control equipment acquisition and operating savings should logically compel the smaller foundries to resort to reducing the door opening. For small foundries, the stack gas volume for given melt rates could then be practically controlled and groups placed in the last tentative screened group, shown on Figure 4-7 on the basis of blast volume. An additional step might include provision for very special metallurgical situations where extremes in iron carbon ratios or blast rates might be encountered.

Such screening should optimally result in working groups of five to ten foundries which would act jointly as discussed in Section 5.

4.2 Effect on Equipment Cost

This section will show that, if such groups act in concert, savings can reasonably be expected to accrue from equipment specifying and purchasing, and perhaps in financing. In attempting to establish equipment saving ranges, two alternatives were considered:

1. Changing melting process to use reverberatory furnaces and,
2. Buying a wet scrubber and associated devices.

4.2.1 Reverberatory Furnace

The study did not permit an in-depth analysis of melting alternatives, and the savings that might ensue from bulk buying. Since this study was primarily concerned with the smaller plants (2 to 10 TPH), reverberatory furnaces were investigated as an alternate to cupola melting for plants of 4 TPH and less. Many of the remaining small gray and ductile foundries in Philadelphia have switched to reverberatory furnaces over the past two years. One of the manufacturers of such furnace offers the following cost comparisons shown in Table 4-D, which has not been fully verified in the study. Costs for better scrap control (smaller size and dry) and recent and continued anticipated increases in both demand and use charges for electricity could modify these figures.

Electricity charges have been relatively constant, and in some cases, even decreasing prior to the last two years, where load growth did not counteract the rapid increase in cost of money and increased capital expenditures or process changes for pollution abatement. Oil prices have sizeable fluctuations, perhaps due to the international nature of control where prices have less relation to market demand. Coke, produced from coal, follows coal prices which have increased appreciably in 1969 and 1970.

As in any new process change, there is also a learning period with some attendant difficulties. The melt rate with reverberatory furnaces is also lower than cupolas, generally one ton-per-hour. Recently two ton-per-hour units have been installed. In the course of the study, a foundry with two one-ton units and another with the first of two, two-ton units were visited. Several foundries are contemplating the use of two or more reverberatory furnaces to obtain the needed melt capacity.

Table 4- D

ECONOMIC COMPARISON - GRAY IRON MELTING, 2 TONS/HR.

Source: Reference 4

Cost Element	Cupola	Induction	Reverberatory Furnace
Electrical demand (@\$1.00/Kva/mo.)	335 Kva \$ 0.10	1250 Kva \$ 2.98	\$ 0.10
Electrical energy (@\$0.01/KWH)	25 KWH \$ 0.25	500 KWH \$ 5.00	\$ 0.23
Coke (@\$49.95/NT)	8:1 ratio \$ 6.22		
Gas (1,000 BTU/cu. ft) (@\$0.50/1,000 cu. ft)	820 cu. ft. \$ 0.41		
Oil (60 gal./hr.) (@\$0.09/gal.)			\$ 5.40
Refractories (material & labor)	\$ 0.50	\$ 1.10	\$ 1.25
Maintenance (including spare parts)	\$ 0.50	\$ 0.50	\$ 0.50
Labor (@\$3.75/hr.)	\$ 1.13	\$ 1.13	\$ 1.13
Cooling water (@\$0.20/1,000 gal.)	\$ 0.80	\$ 0.76	
Purchased scrap (50% of charge)	\$17.00	\$17.00	\$17.00
Alloy addition & fluxing agents	\$ 6.19	\$ 3.99	\$ 5.00
Subtotal	\$33.10	\$32.46	\$29.23
Melting loss	10% \$ 3.31	1% \$ 0.32	1% \$ 0.29
Melting cost/ton	\$36.41	\$32.78	\$29.52
Depreciation & interest	\$ 3.12	\$11.70	\$ 2.07
Pollution control, opera- tion & maintenance	\$ 0.42		
Depreciation & interest	\$ 5.46		
TOTAL OPERATING COST	\$45.41	\$44.48	\$31.59

In addition to the small size, a latent problem in reverberatory furnaces may be in-plant noise pollution which now requires more concern because of the new Industrial Health and Safety legislation. Nevertheless, a reverberatory furnace is deserving of thorough examination as a melting unit for the foundry with 4TPH melt rate or less.

For that reason, 14 companies, reported by a foundry publication as makers of reverberatory furnaces, were requested to submit prices as a function of quantity. (See Exhibit 3 for budgetary request.) Nine replies were received, of which six stated that they did not manufacture such units, and three provided prices as a function of quantity, with the following results.

Table 4-E

Reverberatory Furnace Savings as Function of Quantity

<u>Number of Units Purchases</u>	<u>% Savings Over Each Vendor's Unit Buy</u>			
	<u>Bidder 1</u>	<u>Bidder 2</u>	<u>Bidder 3</u>	<u>Average</u>
5	5	5	4.6	4.86
10	10	10	6.9	8.97
20	15	20	9.4	14.8

Two of the three vendors offered units with a maximum one ton per hour rate, and one vendor stated that he had a unit capable of two tons per hour melt rate (one of these installations was visited). The two vendors with one ton maximum melt rates had unit prices significantly different from each other, but clearly stated unit savings as above.

4.2.2 Wet Scrubber

A budgetary request, shown as Exhibit 1, was prepared, and 27 device manufacturers were asked for a budgetary planning proposal. Fourteen replies were received as a result of this request. Many of the manufacturers who responded gave very limited data - a partial page letter and company brochures. One company stated that there would be no price breaks for quantity buys.

The budgetary request noted that a manufacturer could propose either a baghouse or wet scrubber. Only one company proposed both, and no company proposed only a baghouse. This may have been due to limited responses from those companies who are primarily baghouse manufacturers.

An analysis of the four budgetary estimates that were most complete shows the following:

Table 4-F

<u>Number of Units Purchased</u>	<u>% Savings Over Each Vendor's Unit Buy</u>				
	<u>Budgetary 1</u>	<u>Budgetary 2</u>	<u>Budgetary 3</u>	<u>Budgetary 4</u>	<u>Average</u>
5	18%	14%	5%	16.3%	13.3%
10	22.4%	20.5%	10%	21.5%	18.6%

The responses received had wide variations in prices. This was possibly due to the fact that we requested "budgetary estimates". Because there was no way short of detailed discussions with all vendors to resolve differences which would have been too time consuming for this project, we held discussions with four vendors who had submitted the most complete responses. These are the results, as shown in Table 4F above. Unit prices submitted by

these vendors were:

\$76,230
90,500
60,000
82,400

with an average price of \$77,282. Based on this average price, and using the average of 18.6% savings for ten identical units from these vendors, the purchase price for ten units bought separately would be \$772,820, and for a group operation, \$629,076, a reduction of \$143,744.

The interconnection piping and installation costs would probably run nearly as high⁷ as the costs for the gas conditioning and control device noted above. This study did not investigate installation commonalities that would be conducive to economies of scale because the likelihood of sizeable efficiencies seemed small, and the amount of investigation required was very extensive and therefore beyond the scope of this program.

There are two other elements of cost which yield large economies of scale, and which are ancillary to the equipment.

Stack testing costs can be significantly reduced by testing several stacks in a given industry. The following cost reductions were actually encountered by the authors in another program where they obtained quotations from three companies as a function of quantity of plants tested, and they had eight stacks tested in one industry in a 30 mile radius (see Exhibit 2 for bid form). The same type of approach was used on scaffolding. Although the cost figures were experienced in another industry, we see little risk in their extrapolation to the foundry industry.

A reduction of 50% of a single stack test is possible if eight or more stacks in the same industry are tested. Although the % saving is high, the

absolute savings are not as dramatic. The tests for ten plants done individually would be on the order of \$24,000, with a ten-member group saving of \$12,000. As stated earlier, stack tests are seldom performed to specify equipment, but frequently are performed after equipment is installed to test for compliance with applicable regulations.

Costs associated with preparing a stack for testing were also examined. Under the Federal Register of August 17, methods 1-5 deal with stack sampling and, in part, require a train to catch condensibles. This train is connected to the end of the pitot tube, and is of such bulk and weight that it must be supported during the tests. Therefore, a scaffolding providing more working room near the test points than necessary previously, must be utilized. For good test results, the platform should have a space equal to the diameter of the stack plus two feet, and preferably four feet.

Most plants do not have sufficient scaffolding of their own, and rental is necessary. Scaffolding for a 50' high test point above grade rents for about \$150 per month with erection, disassembly and transportation costs two to three times this amount. For a plant acting individually, scaffolding costs including delivery, assembly, disassembly and pick-up would probably be on the order of \$500. By ten-member group operations, the group cost would be reduced from \$5,000 to about \$3,500.

Another sizeable cost which, however, is more difficult to isolate and assess, is the management cost involved in administering a plant's control program from first knowledge that something must be done until a control unit is installed and working, or a process change selected and on stream. There is simply no way to determine these costs on a solid accounting basis. Most small foundries do

not have facility departments where such work is carried on and cost accounting practices of small foundries generally do not have management or senior engineering personnel involved in such decisions scrupulously accounting for their time. Even if such data were recorded, it was not readily available for this study. It was therefore necessary to assess the amount of this effort on a judgment basis rather than a cost accounting basis. This was done in three ways - by discussions with three consultants who customarily provide such services, by discussions with six foundry managers, and by a review of 38 compliance histories in the State of Pennsylvania. The judgment figure estimated was 10% of the equipment installed price. An example that seems to bear this out is a study for small foundries proposed by a leading consultant⁴⁵ at \$3,000 per company, providing at least twenty companies participate. This study covered the various methods and equipment used for melting, the type and quantities of emissions produced in each method of melting, collection efficiencies and cost estimate for acquisition and operation for a particular foundry. This study apparently did not include developing detailed specifications and contract terms, obtaining competitive prices, overseeing the installation and turn on, and securing proper financing. The sum of all of these costs could reasonably be expected to represent 10% of the total installed price for a single plant. If this were accomplished on a group basis, it is estimated that these expenses could be reduced by a net 30%. The net figure contains costs for consultants who would provide such services for the group. Thus the savings by a ten-member group action for the various tasks, excluding financing, which is covered in the next section, would be:

	<u>10 Member Group Savings</u>	<u>% Reduction Over Unit Buy</u>	<u>Basis of Estimate</u>
Testing (including site preparation)	\$14,500	50%	Experience of investigators in another industry for 8 plants
Document for Competitive Buy & Administrative (30% of 10% of Installed Cost)	45,738	30%	Judgment based on previous discussion
Procure Gas Conditioning & Control Device	143,744	18.6%	Average of 4 vendors' responses.
Installation	<u>N/A</u>	<u>N/A</u>	

Group Savings for a ten-member group: \$203,982, or about \$20,000 per company.

* Installed cost was estimated, using Reference 7, as doubling the cost of the basic system, yielding an installed cost of \$152,460.

4.3 Effect on Financing Costs

Section 3 of this report considered variability of costs with financing alternatives. Conventional bank financing, as shown in Section 3.2, has two serious disadvantages; first, the total cost of financing is the highest of the several alternatives, and secondly, the loan period is short, thereby creating a greater financial impact and a possibly disruptive cash flow problem.

Whether a capital gap exists in small business has received much study¹⁹ with conflicting reports of findings, perhaps due in part to the definition of gap. One definition holds that a gap exists if the marginal return on funds invested in small business exceeds the marginal cost of capital or if opportunities

to improve the allocation of scarce financial resources are being lost, due to inadequate financing of small concerns. Another holds that a gap exists if the cost of money to small concerns (the riskless rate of interest plus allowances for differentials in risk and loan administration costs) exceeds the cost of money to large concerns.

In this situation we should be concerned with the second definition of gap because there is no return to the business by virtue of these capital expenditures. In the second definition, the riskless rate may be the same for small and large businesses, but risk and loan administration may be high.

This is the condition prevailing for the small foundry. With a capital need of \$140,000 in a low profit business, it would be practically impossible for a company to avail itself of the optimum financing by way of low interest debenture offerings due to underwriting expenses. A million plus dollar undertaking serving ten such companies would create a favorable administration (underwriting expense) situation. The risk situation, however, still poses a problem to the lenders because of varying financial postures of the member companies, and the possibility that one or more companies of the group could succumb over the period of the loan. Discussions were held with four banks and five investment banking firms regarding this matter, but no commitment could be obtained either way, based on a hypothetical situation.

It should be noted that group savings on financing costs, if available, are not dependent on operations with a group of foundries possessing common technical requirements. The aim of the financing program is to reduce the effective interest rate to the group by lowering the risk and administrative costs associated with the borrowing. This is largely accomplished by increasing

the size of the borrowings to over one million dollars. Thus, the group, for financing purposes, could encompass several of the groups set up for technical reasons, or parts of the groups. It is theoretically possible to include other industries in such a grouping, except that it would complicate the use of existing group vehicles, as described in Section 5.

Actually, in Pennsylvania, (the only state that has this provision), low interest industrial mortgages can be obtained on an individual basis. These industrial mortgages, except for duration, compare favorably in interest costs with debenture offerings. Therefore, group financing advantages would be attractive only in those states not offering individual low interest industrial mortgages, and would not be a big attraction in Pennsylvania.

4.4 Group Relations with Regulatory Bodies

The specific way the groups would relate to regulatory bodies will depend in large part on the vehicle chosen for group action as described in Section 5. Regardless of the form and charter, the aim of such group activities would be to standardize implementation of controls and regulations, provide better (more informed and more capable) representation to the various regulatory bodies, reduce administration costs, and obtain better control per financial resource expended.

Whatever group representative is chosen, be it a single person, a trade association, committee, etc., that point of contact is considerably more efficient than the present procedure. In Pennsylvania, for example, there are now six air regions, one with two parts--so effectively, seven regions. The individual plants now deal with their respective regional office, the

Bureau of Air Quality and Noise Control in Harrisburg, and the Regional Air Pollution Control Associations. (These associations consist of a representative of industry and labor and a county commissioner of one of the counties comprising the region and a resident of each of the counties).

Rather than ten separate plants with common regulations, emissions, and control strategies explaining their varying plans to one or more of the regulatory bodies, it would be possible for a competent spokesman or small committee to deal more effectively for all the plants with a well thought out compliance strategy. For the regulatory bodies, this would mean they could examine a control program advanced by the group representative in much more detail than would otherwise be the case.

5. Vehicles for Group Action

The preceding sections dealt with regulatory, technical, and financial considerations in determining group size and projected savings. This section deals with possible organizations and procedures (group vehicles) for carrying out such functions relative to pollution control which are expected to result in savings to individual members of the group. Before considering some specific, possible vehicles, a few general observations are in order:

First, the considerations pertaining to such vehicles for group action do not lend themselves to precise numerical or other quantitative treatment, as did those which apply to the technological aspects of the report, or even to the regulatory and financial aspects covered in previous sections.

The reasons why such precision is not achievable for the topic of group vehicles are several. The organizational vehicle's selection, implementation and effectiveness are influenced by non-quantifiable human, legal, and societal factors. The variety of possible forms of vehicles is endless: a listing of those which were at least tentatively considered is given in Table 5-A, which shows ten varieties, and many others could be envisioned without exhausting the possibilities. The varieties of detailed arrangements are also numerous. For example, in a buying cooperative organized to serve as purchasing agent for the group (Item 6 in Table 5-A), there are a variety of ways to constitute the financial structure, management group, admission procedure, and other important attributes.

Second, general observation concerning vehicles for group action is that it is not within the scope of this study to provide a definitive text on organizational vehicles, per se, but rather to provide a survey of several

Table 5-A

POSSIBLE ORGANIZATIONAL FORMS FOR GROUP ACTION

1. Common ownership of multiple foundries
2. Concerted individual action
3. Industry association
4. Joint venture
5. Buying cooperative
6. Limited partnerships
7. Subchapter S corporation
8. Close corporation
9. Development corporation

possible ones, with their salient attributes, so that a reasonable range of alternative possibilities will be presented to those who may subsequently seek to apply the findings of this report.

5.1 Existing Industry Associations

There is no dearth of industry groups and associations which are concerned to a significant degree with gray and ductile iron foundries and which could possibly serve as vehicles for group action of the kind discussed in this report. Table 5-Ba of the Appendix suggests several groups.

There are several such associations of nationwide scope, supplemented by finer subdivisions at the local, or regional level.

Pollution control has been a topic of considerable concern for these associations over the years, to the point that staff experts knowledgeable in this field are employed, that literature⁶ explaining the technicalities is produced and disseminated, that association spokesmen testify at public hearings connected with regulatory actions, and that formal consulting services pertaining to the solution of individual plant pollution problems are available to association members.

An industry association already featuring the existing programs indicated above would appear to be exceptionally well qualified to function as the vehicle for group action, based on commonality of group needs for pollution control equipment. If additional outside expertise would need to be utilized, the skills already existing within the association staff would certainly suffice to make a knowledgeable selection, and also to dovetail the activities of such outside experts with the related internal association activities. The existing links of communications with the members of the industry

could be utilized for all the many exchanges of information which must take place between the vehicle for group action and the members of the group. Cost and time saving reductions in the volume of this information flow could even be achieved by resort to basic information concerning the group members already available to the industry association by virtue of other association activities.

An additional attraction to all concerned, of having an industry association be the vehicle for the group action here contemplated, is the benefit which would tend to accrue from this to other objectives of the association.

Such industry associations, by and large, devote themselves to the advancement of knowledge concerning the production and utilization of the industry's output. For example, the bylaws²⁷ of one such association dealing with the foundry industry state these objectives as follows:

"The object of this Society shall be the advancement of the sciences related to the manufacture and utilization of metal castings through research, education and dissemination of technology."

It is apparent that, in the course of serving as the vehicle for group action in implementing pollution control, advancements in knowledge pertinent to the industry are inevitable.

In spite of all these undeniable attractions of utilizing an existing industry association--or localized subdivision thereof--as the vehicle for group action, it is, in our opinion, not likely that this would come to pass.

This is because there are other factors which militate against this solution. Some of these opposing factors are discussed in Section 6.1. Briefly, however, they revolve around the possibility of conflict between such an activity and certain limitations, partly self-imposed and partly imposed by outside circumstances, which surround the conduct of industry associations.

These limitations have their origin in the desire of such associations generally to secure exemption from taxation, and to stay free of anti-trust violations. The former requires that activities which provide direct pecuniary benefits to individual association members be approached with extreme care (if at all). The latter presents almost the opposite problem, namely that excessively close or intimate collaboration of members via their industry association must also be approached with extreme care. Rather than risk exposure in either of those areas, it is the opinion of the authors of this report that the existing industry associations which would otherwise be eligible for this work would tend to shy away from it.

The fact that existing industry associations might not serve as the main vehicle for group action does not mean, however, that they would have no beneficial relationship to such action. This will be referred to again in subsequent sections dealing with other possible vehicles.

5.2 Special Purpose Organizations

Under this heading there will be discussed two approaches to the provision of a vehicle for group action having quite different characteristics, and correspondingly different stability.

The first of these involves a type of entity which is so structured as to be effectively capable of carrying out only a single group transaction, following which it, in effect, ceases to function. This is treated in Section 5.2.1 below.

The other approach involves the establishment of an entity having some degree of permanence and capable of carrying out a continuity of transactions. This is treated in Section 5.2.2 below.

5.2.1 For Single, Specific Transaction

For a given foundry, the acquisition of air pollution control equipment is normally a one-time transaction. It is true that warranty and maintenance service may continue on for some time, and even that a second installation, or a major upgrading of the first may be necessitated by changes in regulations, but that is the exception; the general rule still is as described above.

It is possible to utilize this one-time characteristic of the situation to advantage in the design of the vehicle for group action. This would be done as follows.

The initiative would be taken by some private organization, not affiliated with any control equipment manufacturer or with the foundry industry, but well qualified by its background and experience to determine the pollution control equipment requirements of foundries, to analyze their commonalities, to create the necessary competitive purchasing documents, and to undertake the complete purchasing function with respect to such control equipment. Capability to assist in financing this purchase should also be available.

Ideally, all these desired attributes would be present in one organization, but even if they cannot thus be found, they can be aggregated through subcontracting. Elsewhere in this report (Section 3), the importance of the financial aspects of the transaction is highlighted. In view of this, if the organization taking the initiative, as discussed in the present section, has less than all the attributes, it would be desirable that it have at least the required financial and management capabilities, while relying on outside assistance for the purely technical phases, rather than the other way around.

In any event, such an organization would deliberately set out to offer its services to a segment--preferably a geographically localized segment--of the foundry industry as the potential group purchasing agent for pollution control equipment.

This is the point at which the foundry-related industry associations come in. Such an association is viewed by the authors of this report as the ideal vehicle, not for actually carrying out the purchasing program, but for conveying to the foundries involved the message which the initiating organization is seeking to bring to them. Incidentally, it should not be thought that such an approach would exclude those who are not members of the particular association. Every such industry association of which we are aware knows not only those plants which are its members, but also those which are not, if for no other reason than because it is desirous of expanding its membership to include the latter. Moreover, in a field of activity as charged with social

significance as pollution control, it seems probable that an industry association would not choose to limit its service as an information dissemination source in this field strictly to formal membership. Finally, the method of dissemination itself, such as the association magazine, newsletter, or other quasi-public medium would inherently reach beyond the membership group.

To the group of foundries so notified, the private firm taking the initiative would then offer a program of voluntary participation designed to lead, in a series of carefully measured steps, to the consummation of all the various aspects of group action.

This program could suitably consist of three principal steps.

Step 1 would be concerned primarily with the interface between technology and regulatory action. The pollution control regulations prevalent in the geographical area in which the program is being implemented would normally be well known to the firm taking the initiative. The only departure from this is the possibility that these regulations might be in, or be threatened with an impending state of flux (as is the case as of this writing in Pennsylvania due to the incomplete state of the new Pennsylvania implementation plan being formulated under the Clean Air Act of 1970). For the case where such a state of flux exists, it would be the responsibility of the initiating firm during Step 1 to resolve the uncertainties before progressing to Step 2.

Also as part of Step 1, it would be the responsibility of the initiating firm to conclusively determine the existing state of the emissions from the participating foundries.

In the three areas of Pennsylvania with which the present study is particularly concerned, this emission determination process would be partly theoretical, and partly experimental. The theoretical part would include a review of the information which the participating foundries have previously supplied to the state as part of the governmental program of creating an emission inventory. It would also include a detailed study of the melting practices of each foundry, in regard to all these variables which importantly affect pollutant emission, (see Section 4 of this report). The theoretical part would also include emission calculations based on the data developed as described above using emission factors such as devised by McGraw and Duprey¹⁷, and taking into account the theoretical effects of pollution control equipment already existing at the particular foundry. These theoretical considerations would be employed, to the fullest extent possible, to identify those participating foundries which need do nothing further, because they are already in compliance with the applicable regulations. In the infrequent situations where such a decision cannot be made with confidence, the theoretical analysis would be supplemented with stack sampling.

This stack sampling would be of a sophisticated, systems-analysis type. This is to distinguish it from most stack sampling efforts, in which there is little, if any, coordination between those knowledgeable of the processes and process variables within the foundry and those who actually perform the stack sampling work. In these uncoordinated situations, many potentially crucial variables are either not considered at all, or are not systematically explored in a way which gives test results that truly represent the emissions encountered under the various conditions of actual and potential

foundry operation.

As shown in the cost breakdown of Section 4 and Table 4-F, the savings which accrue to each individual foundry from its participation in even a modest-sized group for the purposes of Step 1 outlined above, are so significant that financial considerations are not likely to be a major deterrent to participation in this step.

From the above actions, a matrix can then be constructed showing, for those participants for whom additional controls are necessary, what the extent of such additional measures would be.

Thus, as shown in Table 5-C, the results of this step might be that, of 20 participating foundries studied, 3 need nothing more, 7 need only upgrading of their existing wet scrubbers by increasing the pressure drop, and the remaining 10 need new high-efficiency collection equipment.

Proceeding now to Step 2, this step focuses on the commercial activities preceding the actual carrying out of the control equipment acquisition actions whose necessity was indicated by Step 1. In Step 2, the foundries previously found to be in compliance need, of course, not participate. With respect to those which are not already in compliance, there would be developed, in Step 2, the specific technical equipment requirements and documents describing these in terms which enable equipment manufacturers to make informed bids. In addition there would be made the preliminary approaches to sources of financing for this equipment. It is in this Step 2 that the definitive action groups would be firmed up. Referring again to Table 5-C, it is in this Step 2 that it would be determined whether all ten of foundries B, D,

Table 5-C
Preliminary Classification By
Theoretical Analysis and Stack Sampling

Foundry	Control Requirements		
	Already met	Upgrade Existing Equipt.	New Equipt.
A	X		
B			X
C		X	
D			X
E			X
F	X		
G		X	
H			X
I		X	
J		X	
L			X
M			X
N	X		
O		X	
P			X
Q		X	
R			X
S			X
T		X	

E, H, K, L, M, P, R and S actually form one group, from the standpoint of their commonality of pollution control equipment needs, or whether some other subdivision of these ten foundries is necessitated by the technical/regulatory exigencies of the situation.

It should be noted that, irrespective of the definitive composition of the groups which finally emerge, the documentation developed in Step 2 will exhibit so much commonality of material, particularly with regard to equipment, performance, quality, installation, time of performance, financing considerations, and the like, that substantial economies of scale also manifest themselves in this step (see Section 4 of this report).

Step 3 (the final step of the program) would then consist of obtaining competitive quotes from reputable manufacturers based on the documentation evolved in Step 2, placing quantity orders with the lowest responsible bidder, and actually concluding the financing arrangements.

An important point should be noted about Step 3. The transactions contemplated in this step have an unusual, dual character. The object is to obtain the price advantage of ordering equipment (and preferably also of obtaining financing) on a quantity basis. However, the actual orders placed, and the financing obligations incurred, would be individual, i.e., between each foundry and the equipment supplier, and also between each individual foundry and the financing institution.

Although a potential administrative problem, which must receive adequate concern, it is not seen that this duality presents a serious obstacle to the overall program outlined above. It appears feasible to structure the

terms of the purchase documents in such a way that the equipment manufacturer is bound by his "quantity" price quotation only on condition that, within a specified period of time, formal assumptions of the separate purchase obligations are actually made by the several foundries constituting the definitive group.

Prior to that, it would be a wise precaution if the same group members agreed among themselves how they would hold each other harmless in the event that their individual acquisition prices rose through failure of one or more of the other members to carry through with this assumption of individual obligation.

A possible alternative is to confer upon the initiating firm as irrevocable power to act as agent for each of the foundries in the group in the acquisition of this equipment. It is the opinion of the authors of this report that this would be less palatable to the individual foundry operator because it would be more restrictive of his ultimate freedom of individual action. Moreover, this alternative would not solve the parallel problem, which is likely to be encountered in the financing activities, and which involves committing the credit of the individual plants to secure their respective financing shares. It would, in practice, be more difficult to delegate these credit commitment powers to the initiating firm, than to have them retained and exercised by the individual foundries themselves.

In all of the foregoing activities, it would be desirable, although

not essential, if an industry association could continue to participate, in the sense of following the activities in progress, and serving as a central contact point for foundries wishing to participate.

In summary, under this arrangement, no special vehicle to implement group action need be formed. Instead, existing entities are utilized in their respective spheres of capability. The group action is implemented in several steps, progressively narrowing the participants into their more common groupings. Not until the final step (Step 3) is it necessary for them to make major commitment of resources, at which point they have already had the opportunity to experience the advantages of preliminary group action in Steps 1 and 2.

5.2.2 Of Extended Duration

The arrangement described in Section 5.2.1 above, is essentially self-liquidating since, once the three steps outlined therein have been completed, nothing remains to be done of a group nature and the group, as such, ceases to exist.

The way to extend the duration of effectiveness of this arrangement would then entail the formation of a new group of participants, based on a new community of interests, such as a new geographical location.

If, on the other hand, it were desired to establish an organizational vehicle of more permanent character, a different route would have to be followed.

This route would involve the initial formation of an organization inherently capable of cohesion over an extended period of time. In order to have such capability, the organization in question would have to meet certain requirements. First, it would have to possess a more or less persistent source of income from which to finance its operations. Secondly, it would have to have a more or less persistent course of conduct to pursue. Thirdly, its existence would have to be in proper legal form. Last, but by no means least, it would have to cope, right from the outset, with the myriad of other considerations which surround organizations having some degree of permanence, such as tax status, ownership distribution, managerial staffing, contractual rights and liabilities, as well as liabilities imposed by law, independently of contractual arrangements, and so forth.

In considering this array of matters to be dealt with, the question which arises is whether the benefits to be derived from such an organization would outweigh the difficulties posed by its creation and maintenance.

When dealing with the specific subject matter of this study, namely gray and ductile iron foundries in three specific areas of Pennsylvania, the answer to that question appears to be in the negative.

The total number of foundries in these three areas is about 44. Not all of these will be suitable for inclusion in commonality groups--in some areas such as Philadelphia County because they have already complied, and in others because they do not care to take part, or because some other factor keeps them from doing so. The total number served by such an organization would probably be less than 30. The pressure on these foundries to comply (if they have not done so

already) is heavy and immediate. Therefore, prompt action, taken nearly simultaneously, is mandatory for those which remain eligible for group action. Thus, a permanent organizational vehicle appears to be ill-matched to the practical situation which prevails, since it would find itself without useful activity to perform, once the existing, immediate requirements are met.

For the sake of completeness, however, consideration has also been given to what the nature of a suitable vehicle might be, if the practical situation were otherwise, i.e., if the practical situation happened to be one in which there would be a steady demand for the services of such a vehicle, over an extended period of time. In such a situation, it turns out that serious consideration should be given not only to setting up an ordinary business corporation to act as the organization vehicle, but also to a buying cooperative.

Buying cooperatives as such are not new, having been used quite extensively in the grocery, automotive parts, gasoline and dairy industries. On the other hand, the authors of this report are not aware that a buying cooperative has been utilized in a situation like the one contemplated here, namely, to acquire through group action several separate installations of pollution control equipment for separate users. There are instances where a single facility has been provided to serve in common all the members of a group, but none of which we are aware, in which each member of the group needs his own separate facility.

The characteristics of an ordinary business corporation are too well known to require detailed comment here. Suffice it to recall that it can be organized to serve virtually any legitimate business purpose, that it can

have as lengthy existence as desired (even in perpetuity), that it can operate in diverse political jurisdictions, that it can enter into contracts independently of its owners (the stockholders) and that, for ordinary purposes, it insulates its owners from liability (but see Section 6.1, below).

The characteristics of a cooperative are appreciably different²⁹.

First--and perhaps foremost--a cooperative is not organized for the sake of deriving profits for the owners of its capital from the operations of the cooperative. This is not to say that a cooperative is an institution concerned with charitable, or other public endeavors. To the contrary, a cooperative is concerned specifically with providing economic benefits to its members, but these benefits accrue directly from its operations on behalf of the members, rather than from other business activities not involving the members themselves.

The characteristics which principally make cooperatives attractive in the context of the kind of group action here contemplated are the following. First, it is customary in cooperatives to impose limitations on membership. The limitation must, of course, not be arbitrary, but reasonable in the light of the purposes to be pursued by the cooperative. Subject to that limitation, however, the membership can be limited to those pursuing similar objectives. Secondly, the cooperative represents a form of organization in which, by virtue of the customary equality of membership control, members of significantly different inherent economic power can affiliate with one another--for the particular cooperative purpose--without concern for these economic differences. Thirdly, because of its inherently non-profit character, a cooperative can often escape taxation (particularly federal) on its own excess of receipts over expenditures,

by distributing that excess to its members on some appropriate basis, such as in proportion to the respective amounts of patronage derived from them.

The organization of a cooperative is a matter which requires a great deal of care. The statutes of the jurisdiction within which such an entity is to be organized must be consulted to determine the requirements of any applicable special legislation. Whenever permitted, a corporate form of cooperative organization should be evolved, as this tends to insulate members from individual liability, and also because it is conducive to more orderly administration of the cooperative's affairs. Initial financing for its operations has to be obtained, keeping in mind that, as in the case of other organizations, lack of operating funds can prevent a cooperative from discharging its intended functions.

With regard to what these functions should be, there are two basic possibilities. One entails having the cooperative actually acquire (through purchase or lease) the pollution control equipment needed by its members, for subsequent resale or sublease to the individual foundries. The other possibility entails having the cooperative serve merely as a bargaining agent for the individual foundries themselves, the final orders being then placed by each individual foundry. In either case, it appears that there would be no impediment to the cooperative providing the expertize which is needed to define the commonality groupings among its members, and to aggregate the resulting orders for comparable equipment in order to obtain the desired advantages of group purchasing.

In this latter case, the legal principles surrounding the concept of agency also come into play and have to be taken into account in the formation and organization of the cooperative.

Pennsylvania happens to have special legislative provisions which could be utilized in the formation of a cooperative for the purposes described above³⁶. Unlike ordinary business corporations, cooperative corporations under that law do not exempt their members from all individual liability, but make them fully liable, jointly and severally, for debts, for labor or other services performed for the cooperative. With respect to other legitimately incurred debts, on the other hand, each member is liable only to the amount of his unpaid stock.

In summary, it appears that, in the specific situation investigated in this study, a permanent organization for implementing group action does not appear warranted. If one were warranted, a buying cooperative should be seriously considered.

5.3 Governmental Corporation

In some respects, a governmental corporation would represent an ideal vehicle for group action. This is because such an entity would not have to contend with many of the potential impediments to group action which attach to other vehicles, such as credit standing, antitrust considerations, liability to taxation, and so forth.

On the other hand, the use of a governmental corporation to act as the executing arm for group action on the part of private business concerns is not known to have any real precedent. Nor are we aware of any legislation which would a priori authorize the establishment of such a corporation. Its formation would, therefore, become such an innovative act that political

considerations become dominant in determining its feasibility, and its structure if it should be implemented.

Such considerations are beyond the scope of this study.

5.4 Quasi-Governmental Financial Organizations

Within the geographical areas with which this study is primarily concerned there operate several types of organizations, formed under special statutory provisions, to assist business and industry with problems which are of special concern to government.

A list of these types of organization is given in Table 5-D. It should be noted that, under the designations of "Local Development Authorities and Corporations", as well as under "Small Business Investment Companies", there are really included many separate, individual entities, differentiated on a geographical basis. Thus, there are really many more such separate entities than are specifically shown in Table 5-D.

An interesting thing about these organizations is that they have heretofore displayed a pronounced tendency to confine themselves to assisting business and industry with respect to financing. However, the legislation which created, or at least authorized the creation of some of these organizations, does not necessarily require that they confine themselves to financing activities.

For example, the legislation which authorized the formation of localized Industrial Development Authorities²⁴ does not appear to contain any restrictive language which would preclude such an authority from serving as the formal vehicle for the type of group action here contemplated.

Table 5-D

GOVERNMENTAL & QUASI-GOVERNMENTAL ORGANIZATIONS

1. Pennsylvania Industrial Development Authority
2. Local Development Authority & Corporations
3. Pennsylvania Development Credit Corporation
4. Small Business Investment Companies
5. Small Business Administration
6. Economic Development Administration

Being a quasi-governmental body, such an authority should have little difficulty securing the cooperation of industry organizations--preferably of comparable geographical scope--and of government regulatory agencies in order to identify those members of industry within its bailiwick (e.g., those foundries within its territory of operation) that could potentially benefit from group action. From there on, the authority could take the lead in conducting a program, on behalf of these potential group-action foundries analagous to that described in Section 5.2.1, above.

It is not probable that the authority involved would have on its staff the particular skills needed to deal with the specialized aspects of the pollution control problem. However, these skills can readily be supplied by outside, advisory bodies retained for this purpose by the authority.

6. Special Problems

Pollution control measures present serious problems for individual foundries, such as definition of what is needed, affordability, protection from obsolescence, diversion of management talents, etc. When viewed from the perspective of group action, some of these problems are susceptible of being greatly alleviated. Thus, definition of what is needed can be improved through cost sharing of expert advice among group members; affordability can be enhanced through quantity purchasing and possibly also through less expensive financing; and so on.

Other problems, on the other hand, are either aggravated by, or would not arise at all were it not for the fact that group action is contemplated. These other problems are primarily not in the technical area of pollution control, but in peripheral areas, such as the legalities of the contemplated conduct, the human element entering into the picture, and so forth.

Several of these special problems are discussed below.

6.1 Permissibility of Group Action

Foundries within geographical proximity of each other are actual or potential competitors with respect to the products which they make.

From this basic fact stems one source of concern, namely whether the kind of group action contemplated herein is permissible under the anti-trust laws which restrict the extent to which competitively situated businesses can act in concert.

There are, primarily, four pieces of legislation to consider.

These are the Sherman Act, the Clayton Act, the amendments to the Clayton Act contained in the Robinson-Patman Act, and the Federal Trade Commission Act. It should be noted that these are federal laws. While some states have legislation of their own which bears on this issue, Pennsylvania is not one of them. Accordingly, foundries located in the specific areas of Pennsylvania here under consideration need concern themselves in practice only with the impact of federal legislation.

Even this circumscription of the area of concern unfortunately still leaves an extremely broad territory open for consideration. The subject of antitrust is one of the most difficult and uncertain of all the areas of the law. The controlling statutes are generally very broadly worded, the interpretation is left largely to the courts, which do not hesitate to impose widely divergent standards of conduct within the broad statutory mandate, and the whole area is fraught with socio-political significance which leads to further lack of agreement among different interpreters. Moreover, the penalties for violation can be extremely onerous. Not only can conduct which is found to violate the antitrust laws be prohibited for the future, but monetary damages, fines, and prison sentences can be imposed. In addition, in some cases, heavy punitive damages can be awarded even to private litigants.

In view of all this, it is clearly beyond the scope of this study to provide a definitive treatment of the antitrust implications of the contemplated group action. However, it is desired to highlight two distinct areas of antitrust concern which are especially conspicuous in this situation, and to make recommendations for dealing with them.

One of these areas of concern is that of price discrimination. Under the antitrust laws, and particularly the Clayton and the Robinson-Patman Acts, it is unlawful for a seller to furnish equivalent goods to different customers at different prices. This prohibition, subject to certain qualifications which are discussed below, attaches not only to the seller, but also to the buyer, who either passively accepts or actively induces such discrimination in his favor.

In the present situation, one of the important objects of group action is precisely that of obtaining what is needed, at a unit price below that which each member of the group would have to pay if he were acting alone. On the face of it, this would appear to be just the kind of prohibited discriminatory situation envisioned above. Fortunately, there are other factors which can be brought into play to overcome this apparent obstacle.

The one which is likely to be of the greatest practical assistance is that differences in the prices at which goods are sold are not prohibited when they are factually attributable to differences in the costs which the seller experiences in the respective transactions.

This feature of the antitrust situation is not attributable to judicial interpretation, but is actually embodied directly in the legislation. Thus, Section 2 (a) of the Clayton Act (as amended by the Robinson-Patman Act), which provides in substance that it is unlawful for sellers to discriminate in price, also contains the further express reservation

"that nothing herein contained shall prevent differentials which make only due allowance for differences in the cost of manufacture, sale, or delivery resulting from the differing methods or quantities in which such commodities are to such purchasers sold or delivered:" [15 U.S. Code, Section 13]

The second factor which has the potential of overcoming the obstacle to group action presented by the antitrust prohibition against price discrimination involves the concept of meeting a competitor's price.

This feature of the antitrust situation also has its root in a specific provision of the legislation. Thus Section 2 (c) of the Clayton Act (as amended by the Robinson-Patman Act), which provides in substance that the accused violator has the burden of showing justification for price discrimination, also contains the express further proviso:

"That nothing herein contained shall prevent a seller rebutting the prima-facie case thus made by showing that his lower price...was made in good faith to meet an equally low price of a competitor," [15 U.S. Code, Section 13]

The third factor which tends to overcome the obstacle that might otherwise be posed by antitrust prohibitions against price discrimination is one that peculiarly affects the buyer. Referring once again to the Clayton Act (as amended by Robinson-Patman Act), and particularly to Section 2(f) thereof, what is prohibited by same is

"knowingly to induce or receive a discrimination in price which is prohibited by this section" [15 U.S. Code, Section 13]

This is the section which is deemed to control the actions of the buyer in a price-differential situation. The fact that, unlike the other

sections previously quoted, this section attaches responsibility only when the buyer has knowledge of a violation by the seller is significant. It should be noted, in this connection, that what is involved here is not simply a question of actual knowledge. Rather, knowledge of a violation by the seller can be imputed to the buyer from the circumstances of the transaction. This is sometimes covered by the term "trade experience"²¹, which signifies that the experience of the buyer in the customs of the trade can be such that he would be deemed to have known of the existence of an unjustified discrimination, even though he actually did not.

Turning now to the second distinct area of antitrust concern, this is the one which is sometimes referred to by the term of exclusive dealing²². This is a problem area which is not traceable to a particular section, or subsection of a particular statute, but stems from the various, general prohibitions against activities which diminish competition at any level.

The problem which is involved here is that, once a group of foundries has decided to make a quantity purchase of pollution control equipment from a given supplier (in order to obtain the benefits of lower unit price stemming from such action) then, by that very act, other potential suppliers of such equipment are precluded from sales of same to the members of that group. These other potential suppliers can therefore conceivably consider themselves as being victimized by exclusive dealing practices benefitting a competitor.

This is an area in which, unfortunately, the exculpatory conditions are not as clear-cut as in the area of price discrimination discussed

previously. However, extensive discussions in the literature, such as those which emanated from an extensive study of the antitrust laws conducted under the sponsorship of the United States Attorney General ²³, suggest that it is systematic exclusion of competitors from access to a substantial market which is the crux of this problem. Thus, it would appear that if the exclusion of those suppliers who are not chosen by a group is the result of a normal business selection process covering needs which do not extend beyond those currently existing, this would not be objectionable.

With regard to antitrust considerations generally, it should be noted that, in the absence of a specific exemption in the legislation, it is quite immaterial in what organizational format the action under consideration takes place.

For example, if the group action contemplated by this study took place under the aegis of an industry association, this would not immunize either the group or its individual members from possible antitrust problems, any more than if it were carried out by an ordinary profit-oriented business corporation, by a buying cooperative, or whatever.

In fact, if anything, industry associations may have to be more cautious than other, more ad hoc vehicles of group action. The reason for this is that the permanent affiliation of competitors in industry associations has tended to surround these associations with a general aura of antitrust concern. This must be taken into account in considering an industry association's relationship to such group action (see Section 5.1, above).

With respect to buyers cooperatives, an additional observation is

also in order. Section 4 of the Robinson-Patman Act contains an oft-mentioned provision authorizing cooperatives to return to their participants shares of earnings based on patronage proportions. This fragment of the statutory antitrust edifice has sometimes been used in attempts to show that cooperatives are exempt from antitrust restrictions. It is, however, very doubtful that such is the case. Rather, it appears that cooperatives (unless otherwise expressly exempted) are on the same antitrust footing as other organizations, except with respect to their method of distributing benefits, as sanctioned by the above-mentioned provision^{31,32}.

In summary, however, no inherently insuperable obstacles appear to be created by antitrust considerations.

With regard to permissibility of group action, there is one other topic which needs to be at least indicated for consideration. That is the topic of security regulation.

To the extent that group formation entails the acquisition by group members of something equivalent to an investment interest in the group vehicle, there is the possibility that this interest may be subject to regulation under the federal Securities Act of 1933, the federal Securities Exchange Act of 1934, or a state securities law, commonly referred to as a "blue-sky" law. These are all laws which essentially regulate the amount of information which must be conveyed to those who acquire such an interest, and impose penalties for dealing in such interests without making the necessary disclosures, or otherwise failing to adhere to the regulatory scheme.

Pennsylvania is one of the states which has a "blue sky" law³³. Although it does not require registration of securities, per se, it does impose controls on dealing in securities, by means of which it accomplishes the equivalent effect.

Both the federal laws and the Pennsylvania Securities Act have numerous exemptions, and these would have to be carefully scrutinized, to determine if a particular contemplated group arrangement falls within them. If not, then the applicable disclosure and licensing provisions would have to be strictly followed.

To illustrate the complexity of this subject area, it is noted that the Pennsylvania Securities Act provides 17 distinct bases for possible exemption from the requirements applicable to those who are deemed to be "dealers" in securities and 7 other specific bases for exemptions of those who would otherwise be deemed "investment advisers".

Within these statutory sections, there are then additional ramifications. For example, although one of the 17 exemptions mentioned above is for the case of issuance of its own securities by a corporation not organized for profit, a regulation promulgated by the Pennsylvania Securities Commission³⁴ provides that those who for profit assist in the preparation of a financing method and distribution plan, even for such a not-for-profit corporation, is nevertheless bound by the provisions of the Act applicable to investment advisers.

These regulations are then further amplified by interpretations. One of these³⁵ is close to home, since it deals with non-profit housing

cooperative, which it regards as non-exempt under the not-for-profit exemption previously mentioned.

Because disclosure entails expense, it is tempting to take advantage of exemptions, or even seeming exemptions. However, to prevent this matter from jeopardizing the success of the groups effort, it would be the position of the authors of this report that strict compliance with the applicable regulatory schemes is to be preferred.

6.2 Enabling Legislation

The area of pollution control, in general, is one which has evolved so drastically in recent times, that possible industry reaction patterns must be considered which have little or no precedent and which therefore had not been contemplated when the structure of laws and regulations was evolved within which these reactions must take place.

To illustrate, Pennsylvania has a law²⁴ which provides for financing of plants and facilities through mortgages exempt from federal income taxation. This is referred to in Section 3, above, in connection with financing considerations. However, it is also pertinent here, because the wording of this law was originally such as to apparently preclude its application to pollution control equipment because the installation of such equipment ordinarily did not involve construction of a building. The desire, which had mounted since the original enactment of the law, to extend its benefit more fully to pollution control, led to the introduction of amendatory legislation²⁵, designed to clearly eliminate the above-mentioned impediment. Such legislation, as of this writing has been enacted by the Pennsylvania legislature and awaits

signature by the Governor.

Other specific areas of legislation based on this type of consideration are discussed below.

6.2.1 Necessity

As appears from other sections of this report (which are predicated on existing legislation rather than on changes in legislation), there are at present no insurmountable legislative obstacles to group action. Thus, it cannot be said that there exists the strict necessity for additional legislation to enable such group action to be successful.

However, there are certain legislative moves which would greatly facilitate the action and improve the results.

Three particularly important ones are:

- (a) Credit support for group members
- (b) Direct government financing for group activities
- (c) Antitrust exemption.

One of the more attractive methods of financing the acquisition of pollution control equipment on a group basis involves the issuance of tax-exempt bonds under the aegis of special governmental or quasi-governmental authorities. This was discussed in Section 3, where it is also pointed out that one obstacle to such financing is the problem of how to utilize the individual credit capabilities of the group members to support the credit requirements of the collective bond issue. This could be readily overcome by extending, to such bond issues, government loan guarantees, analogous to those which are now accorded by the Small Business Administration (SBA) to

the loans of individual concerns. This is the kind of arrangement which is envisioned under item (a), above.

An extension of such an arrangement, again analogous to what the SBA now provides for individual concerns would involve the extension of direct credit to groups [item (b), above], in the event that a guarantee does not prove adequate to permit the floating of a bond issue.

Finally, in order to set at rest any lingering concerns about the antitrust consequences of group action (see Section 6.1, above), a clear-cut antitrust exemption would be in order. This is the intent of item (c), above.

6.2.2 Achievability

The prospects of obtaining legislation of the kind discussed above are not predictable with any significant degree of certainty. Too many factors not susceptible of quantitative evaluation enter into the enactment of legislation. These include executive support, public opinion, fiscal policy, etc.

However, it is of interest that legislative actions which are somewhat comparable to those suggested above have already been taken.

Thus, the SBA is already authorized to provide so-called pool loans²⁶, which inure to the benefit of several small businesses, which have banded together in a corporation to obtain equipment and for other purposes. This, it is believed, constitutes a substantial precedent for federal support of worthy group financing needs.

Likewise, the SBA is authorized²⁶ to serve as the vehicle for

obtaining clearance for the formation of such groups from the Justice Department and the Federal Trade Commission, such clearance then affording an exemption from antitrust requirements for the groups affected thereby. Whether legislation similarly exempting groups formed for pollution control would also be attainable is, of course, not certain. In fact, personal conversations with members of the Justice Department and Federal Trade Commission staff suggest that these agencies are averse to broad antitrust exemptions, even for pollution control. This does not mean, however, that carefully delineated exemptions would not be looked on favorably.

In summary, although the prediction of legislative possibilities is a highly uncertain matter, there are indications that whatever legislation is ultimately needed would not necessarily encounter insurmountable obstacles.

6.3 Persuasion to Group Action

A distinction must be made here between persuasion to action to abate pollution, and persuasion to action in a group for the same purpose.

Legislation, regulatory implementation thereof, and enforcement action, if needed, constitute obvious methods of persuasion to abatement action, per se. In addition, there are such possible factors as public-spirited concern, generalized public relations, relations with stockholders, relations with especially concerned customers, and so forth.

Conspicuously absent from the above list is direct economic motivation. In taking abatement action, whether individually or in a group, there is, of course, an indirect economic motivation, in the sense that all the persuasion factors enumerated above impinge on the economics of foundry

operation and, ultimately, can be translated into costs, against which the cost of the abatement action itself can be offset.

Compared with this, the possibility of group action represents a more direct economic motivator. That is because its economic consequences are more precisely quantifiable for purposes of comparison with non-group action.

In other words, abatement action may have to be taken in any case (unless the extreme solution of economic suicide through plant closing is adopted), but, that being so, group action then commends itself because it reduces the costs (both cash and hidden) of doing so.

The key ingredient in persuading plant operators to participate in group action is therefore believed to be a convincing demonstration of such cost reductions.

There are two methods for demonstrating such reductions. One is by before-the-fact analysis. This method suffers from a potential credibility gap. As this report shows, the over-all situation is so different from the nearest prior parallels that quite a few areas of uncertainty remain at the end of such a before-the-fact analysis. These then become the proper subject of individual evaluation by prospective participants which, if done with prudent conservatism, could well deter participation by many potentially eligible members of the industry.

The second method of demonstrating the benefits of group action is to actually carry through a successful group effort. Although even this would probably not suffice to eliminate all future skepticism, it is believed

that it would greatly reduce it, not only because a demonstrated success inherently possesses greater credibility than an untested proposal, but also because many of the uncertainties which still remain would necessarily have been resolved in the process, and therefore would no longer be subject to individual evaluation by prospective participants for future group actions.

If group action is impeded by lack of a successful demonstration, then it might be asked whether the same circumstance would not also prevent the demonstration itself. The answer to this, it is submitted, lies in the fact that a demonstration can be surrounded with circumstances which it would be more difficult, if not impossible, to maintain for all subsequent group actions, and this could overcome the initial hesitation of prospective participants.

The key here is believed to be avoidance of risk on the part of the participants in the demonstration.

This is achievable in two ways. First, the program should be approached in a series of steps, each designed to establish the feasibility and effect of certain key elements. Secondly, each succeeding step should be taken only as and when success of the prior step has been established. Thirdly, until that step at which clear-cut economic benefits accrue to the individual participants in the demonstration program, these participants should not be responsible for its funding.

The general outline of one approach to such a demonstration program can be taken from the discussion in Section 5.2.1, above. That section describes a multi-step program for group action which can be adapted, for

demonstration purposes, by funding from non-foundry sources an appropriately skilled organization to carry out Steps 1 and 2 and part of Step 3 outlined there. This would bring the demonstration program to the point at which the economies to be realized in the actual acquisition of equipment could be quantitatively ascertained, both from the bids obtained from equipment manufacturers, and from the financing arrangements worked out prior to that point.

It is expected that, from that point on, the program could become effectively self-supporting. Although the non-foundry sources would advance the additional funds needed to carry it to completion, reimbursement of these advances could be incorporated into the structure of acquisition cost to the foundries. It should be noted that this would have the advantage of not only reducing the ultimate outlay for the demonstration program from non-foundry sources, but of also enhancing the realism of the demonstration because it would approximate more closely the conditions which would be encountered in subsequent group actions not enjoying non-foundry funding.

The authors of this report believe, from carefully guarded inquiries directed to this subject, that the elimination of risk resulting from the procedure suggested above, is crucial to implementation of a demonstration program, and that a successful demonstration, in turn, is the key factor in effective persuasion to group action on a wider scale.

6.4 Procedures of Group Action

There are a number of special procedures which require consideration by virtue of the group nature of the actions contemplated in this report.

They relate to such matters as group prospect identification,

membership, administration, and permissibility of group action.

One of the important requirements for successful group action is the identification of prospective group members, and the arousal of their interest in participation. This end can best be served by giving the widest publicity to the possibility of group action. To that end, public bodies such as pollution control regulatory organizations should be fully informed, as such organizations are often viewed by individual foundries as an informational resource on how to deal with pollution control problems. News media--particularly those addressed to the industry--should be fully informed. Most importantly, industry associations should be utilized as vehicles for disseminating information concerning the possibilities of group action (see Section 5.1, above).

With regard to group membership, this should be as non-restrictive as circumstances permit. Breadth of membership has dual advantages. First, and most importantly, the broader the membership, the greater the opportunity for meaningfully large commonality groupings to achieve equipment cost savings, and also for the adoption of cost-saving financing techniques. Secondly, and as discussed more fully below, the absence of restrictions on membership diminishes the possibility of unfavorable antitrust repercussions from plants which are not part of the membership.

It is recognized, of course, that practical considerations will require imposition of some membership limits. One such consideration is the time factor. In many areas, such as the areas of Pennsylvania with which this study has been particularly concerned, the pressure to comply with control

regulations is immediate. If group action is to respond to the resultant need, the formation of definitive groups will have to take place quickly and this, in turn, will have the unavoidable effect of foreclosing membership to prospective participants who do not act quickly enough.

Depending on the specific vehicle for group action, other limitations may come into play. If, for example, the vehicle involves some aspect of governmental aid available only to small business (see Section 5.2.2, above), this would in turn impose inherent limitations on membership. Likewise, if group financing is to avail itself of some quasi-governmental organism of limited geographical operating range, that would impose inherent limitations. Thus a reconciliation will have to be effected between the desirability of broad participation and limiting factors such as outlined above.

With regard to administration, this will be dictated primarily by the form of organizational vehicle which is utilized for group action. However, some suggestions independent of that specific form can be made.

One is to maintain maximum contact with participants. There are likely to be many important occasions for seeking participants' informed views as to the direction which the group program should take. The pertinence of these views will be enhanced if the participants are kept informed step-by-step of what is happening. Likewise, the confidence of the participants in the validity of the group action will tend to be enhanced by their familiarity with what is being done.

Conversely, it is not impossible that certain matters considered to be proprietary by an individual member will have to be ascertained for

the sake of furthering group action. In the financing area, for example, members' financial data may have to be elicited. This requires just the opposite treatment, namely one of strict privacy. Alternatively, it may be possible to arrange for such sensitive financial data to be conveyed directly to the financing institution which would then, in turn, take the responsibility of forwarding to the group only necessary aggregate or appropriately anonymized data.

Finally, with regard to overcoming antitrust obstacles, two procedural matters deserve comment.

First, it is recommended that, on behalf of any organizational vehicle that is ultimately to implement a group action program, two antitrust clearances be sought. One of these should be from private counsel, acting on behalf of the entire organization. The other should be directly from the appropriate government agency, which might be either the U.S. Department of Justice or the Federal Trade Commission.

Secondly, it is recommended that the affairs of the organization be conducted on a completely above-board, impartial and non-discriminatory basis. Thus, the membership should be as wide open as possible, purchasing should be done strictly by competitive bidding among as many suppliers as possible, and so forth. In addition, informality of action should be avoided. Instead, all decisions should be arrived at openly, all steps recorded and documented, and so forth.

6.5 Distribution of Risks and Benefits

There are three principal kinds of risk to a prospective participant

in the kind of group action here contemplated.

One is the risk that, after he participates in the initial stages of exploration and analysis, it develops that his particular foundry cannot logically be grouped with others in the numbers required for economic benefits.

The second is the risk that poor performance on the part of the organizational vehicle would deprive a given group (or some member or members thereof) of the greatest possible benefits of group membership.

The third risk is that some action, or even failure to act on the part of one group member would undercut the advantages that would otherwise have accrued to the group.

All three of these risks are amenable to minimization.

The general approach to such minimization resides in gradualism. By this we mean that, at least in the first few cases of group action (until experience is gained) a gradual approach be adopted. Referring again to Section 5.2.1 of the report, in which some of the steps are outlined into which such a gradual approach could be subdivided, it will be noted that until the end of Step 2, the risk of each participant would be minor, consisting solely of whatever investment was necessary in order to collectively arrive at this stage. This risk is further reduced--as compared with individual action carried to a corresponding stage--by the economies of scale (noted elsewhere in this report) which already make themselves felt in these initial steps.

In the last step (Step 3 of Section 5.2.1), the risk of buying equipment, or of obtaining financing at a cost higher than necessary is

inherently distributed by the mechanism of group action, since any quantity price will still tend to be lower than the equivalent single-purchase price. Moreover, by following the suggestions concerning group membership relations advanced in Section 6.4, above, the risk of improvident action can be reduced through the collective application of the group's acumen on this score.

Finally, the risk that one member's action, e.g., withdrawal from the group, could jeopardize the benefits obtained by the others can be alleviated by the contractual arrangements entered into by the group members not later than at the point of ordering equipment and/or arranging financing. These arrangements would have to include provisions denying a member the right to withdraw, or, alternatively making the withdrawing member responsible for any resulting increase in cost to the remaining members.

With regard to benefits, the distribution would take place automatically, by the reduction in individual foundry costs which would be experienced through group participation at each step of the process.

7. Conclusions and Recommendations

The study has indicated that a sizeable portion of an air pollution control system can be substantially identical for foundries in Pennsylvania having commonalities of:

Melt Rate - To determine allowable emission rate

Blast Rate - To determine stack gas volume where charge door size is known and controlled

Stack Exit Temperatures - To determine the need for gas conditioning equipment.

The control device, a portion of the air pollution control system, is not painstakingly designed for a specific plant based on particle size distribution and measured grain loading since this data is frequently not available, especially in small foundries. Design integers based on experience and rule of thumb with the above-named commonalities are used.

Best methods of connecting the equipment, placement, interconnecting ductwork, foundations, location of electric, water and sewage lines, etc., and installation problems are unique, and are therefore not readily amenable to economies of scale.

Process changes, as for example to reverberatory furnaces for small melt rates, may be an attractive alternative to control devices. A thorough cost analysis is required, however, including impact of the process change on industrial engineering aspects of plant operation before such a choice can be made.

A group of ten foundries of ten ton-per-hour melt capacity could

reasonably expect to save about \$20,000 for each group member by group procurement. The savings on financial arrangements pose more of a problem since there was no accurate way to predict if debenture offerings are possible. If group financing turns out to be possible, a group of ten foundries could also save about \$15,000 for each member's financing charges if tax-free debentures are utilized rather than straight bank borrowing (5 years or less loan). This may require some legislative support.

In addition to the savings, the cash flow picture is improved with debenture financing. The alternative of debenture financing is not available to individual foundries because the fixed costs connected with the procedure, even if buyers for the debentures could be found, would more than consume the interest savings.

The savings noted do not cover some areas which might yield additional savings, and which are not subject to quantitative analysis. For example, competitive price savings, reduced risk due to more thorough technical analysis and improved contract provisions, and tax advantages through better depreciation strategy cannot be measured *a priori*, but common sense indicates they are a cost factor.

A group could be formed to obtain only the acquisition cost savings or only the financing savings, or both. To obtain the financing benefits, all that is needed are numbers of plants. They need not have common technical needs, geographies, or regulations. Indeed, they need not all be foundries.

The major problem inhibiting the adoption of such a group plan, aside from interesting enough foundries who desire to form such a group, is

the fact that there is no precedent for guidance in conducting the group activity. The lack of precedent is compounded by the fact that it is difficult to assess the consequences of certain group operations from a theoretical examination. Two examples will demonstrate this point.

Some concern was expressed at the outset of this study as to the legality of such group activity in regards to antitrust regulations. Considerable time was spent in trying to assess the likelihood of any problem developing, but because of lack of historical data, a firm position could not be established. All the written material that has been examined, and the response from experts contacted relative to this matter indicates that the group can be structured in such a way as to not create a problem in this regard. The best way to cover this is to submit a written description of the proposed activity to the Federal Trade Commission and to obtain an advisory opinion. It is estimated that this procedure will take about three months. A request for such an opinion cannot be submitted, however, without a detailed description of the group organization and proposed activities.

The organization of the group depends in part on the requirements for best group financing. Since this sort of financing activity has not been actually accomplished before, several different arrangements might have to be presented to the financial community, the most appropriate then forming a part of the submission to the Federal Trade Commission.

This lack of precedent dilemma could seriously inhibit the adoption of groups with the goal of obtaining the savings previously stated. Each party to the program--the foundries, the money sources, the government,

and the device manufacturers will be reticent to enter into such an arrangement with somewhat unknown legal and financial pitfalls.

This problem can be overcome by conducting a program in gradual steps. Parties to the arrangement would proceed from what is at first a rather loose arrangement in that they would not be legally or financially bound. As the program proceeds, and the present unanswered questions become answered and the risk eliminated or at least quantified and accepted, the parties would become more increasingly committed until the last phase when they would be firmly committed in a legally binding way.

APPENDIX

EXHIBIT 1

Budgetary Request for Control Device

Collector(s) should be quoted on the basis that connecting input gas ductwork will be provided by others. All input gas ducts will be above charge withdrawals. All necessary power and water lines will be supplied by others. Bidder should specify desired input duct size and necessary power and water connections.

Catwalks, service scaffolding, and foundations will be supplied by others. Bidder is to cover all necessary gas conditioning and effluent removal equipment including fans, controls, valves, rotary air locks, etc., water eliminators, demisters, and exit stacks to the degree necessary to meet the exit loading and Ringlemann requirements are to be included in the bid price.

Elaborate proposals are not necessary at this time. What is required is a brief sketch showing layout and approximate weight and dimensions. Apparatus may be described in brief fashion with reference to company brochures if desirable. Design factors such as pressure drop, number, size, and type bags or if water system liquid make-up rates, liquid injection rates, etc., should be noted.

It is not our intention at this time to specify either a baghouse or wet scrubber. If your company makes both types of units you may propose both. The intent is to obtain budgetary quotations for a basic system without concern at the present time for unique mounting and connection problems.

Bids for three possible quantities of 1, 5, and 10 units are desired with deliveries as follows, except that other delivery dates that reduce cost will be considered. If other dates are used in preparing budgetary proposals, please note them. If this program proceeds, this request for budgetary proposals will be followed by requests for firm proposals based on more detailed specifications, terms, and conditions.

<u>Quantity</u>	<u>Delivery</u>
1	3 mos ARO
5	1 ea. 3 mos ARO 2 ea. 4 mos ARO 2 ea. 5 mos ARO
10	1 ea. 3 mos ARO 2 ea. 4 mos ARO 3 ea. 5 mos ARO 2 ea. 6 mos ARO 2 ea. 7 mos ARO

Although the dust loading, the particulate size distribution by weight of the inlet gas stream, as well as the temperature may fluctuate in actual operation, acceptance test conditions will be held at $\pm 10\%$ of the cited input conditions. The test procedures will be those of ASME 21-1941 and 27-1957.

Budgetary proposals should list separately estimated engineering and production costs. Quoted prices should be F.O.B. your plant and should include no out-going shipping costs nor any installation costs. Packing suitable for rail or truck shall be included. If unit is to be shipped in knocked-down fashion for field assembly, a brief description of the degree

of field assembly necessary shall be included.

It is understood that this budgetary quotation will not be binding on you or give rise to any costs to us.

EFFLUENT DESCRIPTION

Gas Flow 15,000 scfm
Inlet Grain Loading 1.38 grs/scf

Particle Size Distribution by Weight:

<u>Size in Microns</u>	<u>%</u>
> 44	48
20-44	14
10-20	12
5-10	8
< 5	18

Gas Temperature 1600°F
Operating Ambient -10° to 100°F

Particulate Characteristics:

20% Silicon & Calcium Oxides
20% Combustibles
60% Metallic Oxides

Required Performance:

Output Grain Loading 0.068 grs/scf
No more than Ringlemann 1.0

EXHIBIT 2

Stack Sampling Price Request

You are requested to provide a fixed priced proposal for the services, including reports, as noted herein. It is understood that all data and reports obtained from this work are the exclusive property of J.A. Commins and Associates, Inc., and are not to be released to any person, association or company in oral or written form without the express written permission of an officer of J.A. Commins & Associates, Inc. It is anticipated that a contract will be issued for such services by the 15th of November. All field work is to be completed within one month's time thereafter, with reports issued within 7 days from completion of tests at each plant, thus a flow of reports will take place with the last report due 5 weeks from start of the tests.

The prospective contractor should quote based on the assumption that the stack will have two sampling ports properly adapted, and located. Scaffolding to support equipment weighing not more than 200 lbs. will be available at site, and locatable within 8 feet of the sampling ports. 110 volts, 3 phase power will be available at the located scaffolding. Ladders will be used by test crews to gain access to sample ports and equipment which is held on scaffold.

Assume process will be in operation within one hour of crew arrival, and will be in operation for at least five hours.

Location of plants will be within a seventy mile N.W. quadrant of Philadelphia.

Plants will be Asphalt Batching and therefore, although temperatures volumes, etc., are not identical, they will be similar to the degree that the raw material is about the same, processes similar, and the finished product must meet strict, common specifications. Stack temperatures, gas volumes, etc., will be somewhat the same for the given size dryer.

A written report containing data per FR as well as a particle size analysis by weight fraction is required for each plant tested within one week after test.

Quotations should be submitted on the basis of the attached sheet.

No. & Location of Sites	FR*	Particle Size Distribution	Particle Characteristics	Reports	Alternate A		Alternate B	
					Quote 2 in field crew & Complete Reports		Quote Leader and field assistant from JAC Complete Reports	
1 test	X	X	X	X	\$		\$	
2 tests, one at each of two different plants located 40 miles apart	X	X	X	X	\$		\$	
6 tests, two of which are at adjacent plants, same company & location and others scattered in region	X	X	X (for first 2 plants only)	X	\$		\$	
10 tests, two groups of 2 at adjacent plants, other 6 scattered in region	X	X	X (for first 2 plants only)	X	\$		\$	
16 tests, two groups of 2 at adjacent plants, other 12 scattered in region	X	X	X (for first 2 plants only)	X	\$		\$	

*If Method 3 & 4 on 1st two tests indicate good correlation, the same values may be assumed on subsequent tests.

SPECIFICATION FOR STACK SAMPLING

TOTAL PARTICULATES

Tests are to be conducted in strict accordance with the following:

Standards of Performance for New Stationary Sources Contained in Federal Register, August 17, 1971, Volume 36, Number 159, Part II, the following portions:

Pages 15708, 15709 & 15710 for Method 1 - Sample and Velocity

Traverses:

Holes will be pre-located and drilled with 3" female pipe fitting. Location and # of traverse points to be per FR (FR hereinafter refers to aboved-named Federal Register). For bidding purposes assume 12 points.

Pages 15710 and 15711 for Method 2 - Determination of Stack Gas Velocity:

Strict accordance required.

Pages 15711, 15712 for Method 3 - Gas Analysis for Carbon Dioxide, Excess Air, and Dry Molecular Weight:

Strict accordance required. For quoting purposes assume only two such determinations will be required.

Pages 15712 and 15713 for Method 4 - Determination of Moisture in Stack Gases:

Strict accordance required except only two such determinations shall be made.

Pages 15713, 15714, 15715, 15716, 15717 for Method 5 -
Determination of Particulate Emissions From Stationary Sources:
Strict accordance required.

PARTICULATE ANALYSIS

Collected particles are to be analyzed by size in the following groupings
for every test conducted.

<u>Size in μ</u>	<u>% by Weight in grade</u>
-1	_____
1-2	_____
2-3	_____
3-5	_____
5-10	_____
10-15	_____
15-20	_____
20-30	_____
30-40	_____
> 40	_____

Two particulate samples are to be analyzed for:

resistivity

abrasiveness - sharpness

density

hygroscopicity

Contractor is to supply all transportation of his personnel and equipment and all measuring, and analysis equipment and/or services. He shall submit reports on all tests. Contractor shall be liable for any accident to his or plant's personnel arising from the stack sampling activities.

A total of three tests shall be run at each plant.

EXHIBIT 3

Request for Technical & Cost Data

Our company, a private management consulting company not associated with any manufacturer or regulatory agency, is under contract with EPA and a leading foundation to examine several industries with the aim of ameliorating the management and financial impact of air pollution controls. One of the five industries we are studying is the gray and ductile iron foundry industry.

It would therefore be helpful to the study if you could provide us with technical and cost information on reverberatory furnaces and associated equipment used in melting operations in gray & ductile iron foundries. Please note we are interested only in melting operations and not holding, unless this is a secondary function.

We are interested in costs for quantities of 1, 5, 10, and 20 of each type reverberatory furnace manufactured. It is understood that this will represent an estimate only for the purpose of the aforementioned study and not a quotation which would be binding on you or give rise to any cost to us.

Thank you for your assistance in this matter.

EXHIBIT 4

Discussion Guide for Foundry Visits

Section 1. General Information

1. Name & Location of Company _____

2. Location of Foundry if different from above _____

3. Person(s) to contact regarding this visit _____

4. Form of organization: _____ Corporation _____ Partnership _____ Proprietorship
5. Employment _____
6. No. of Shifts operating _____
7. Type of foundry _____ Jobbing _____ Captive _____ Other
8. Production Rate _____

Section 2. Melting Operations

9. Characteristics of Furnace

Furnace #	Type	Type of Blast	Melt Rate	Year Installed	Output	Blast Volume	Operation Period	Diameter (lined)
1								
2								
3								
4								
5								

10. Characteristics of Charge

	<u>Furnace</u>				
	1	2	3	4	5
Melt-to-coke ratio					

Scrap usage _____

Type of coke used _____

11. No. of furnaces operating on a typical day _____
12. Any replacements? _____

Section 3. Control System

<u>Furnace</u>	<u>Type of Control</u>	<u>Year Installed</u>	<u>Depr. life</u>	<u>Gas Volume</u>	<u>Gas Temp</u>	<u>Pressure drop</u>
1						
2						
3						
4						
5						

14. Any stack test results _____

15. Inplant Pollution controls _____

<u>Source</u>	<u>Type of Control</u>	<u>Condition</u>
Pouring		
Shakeout		
Abrasive Cleaning		
Grinding		

16. Is sand recycled? _____

Section 4. Further Information

17. Have been contacted by pertinent control authority?

18. Propose to install control equipment?

19. Considering process change?

20. Financial Information

21. Future Outlook

22. Labor situation

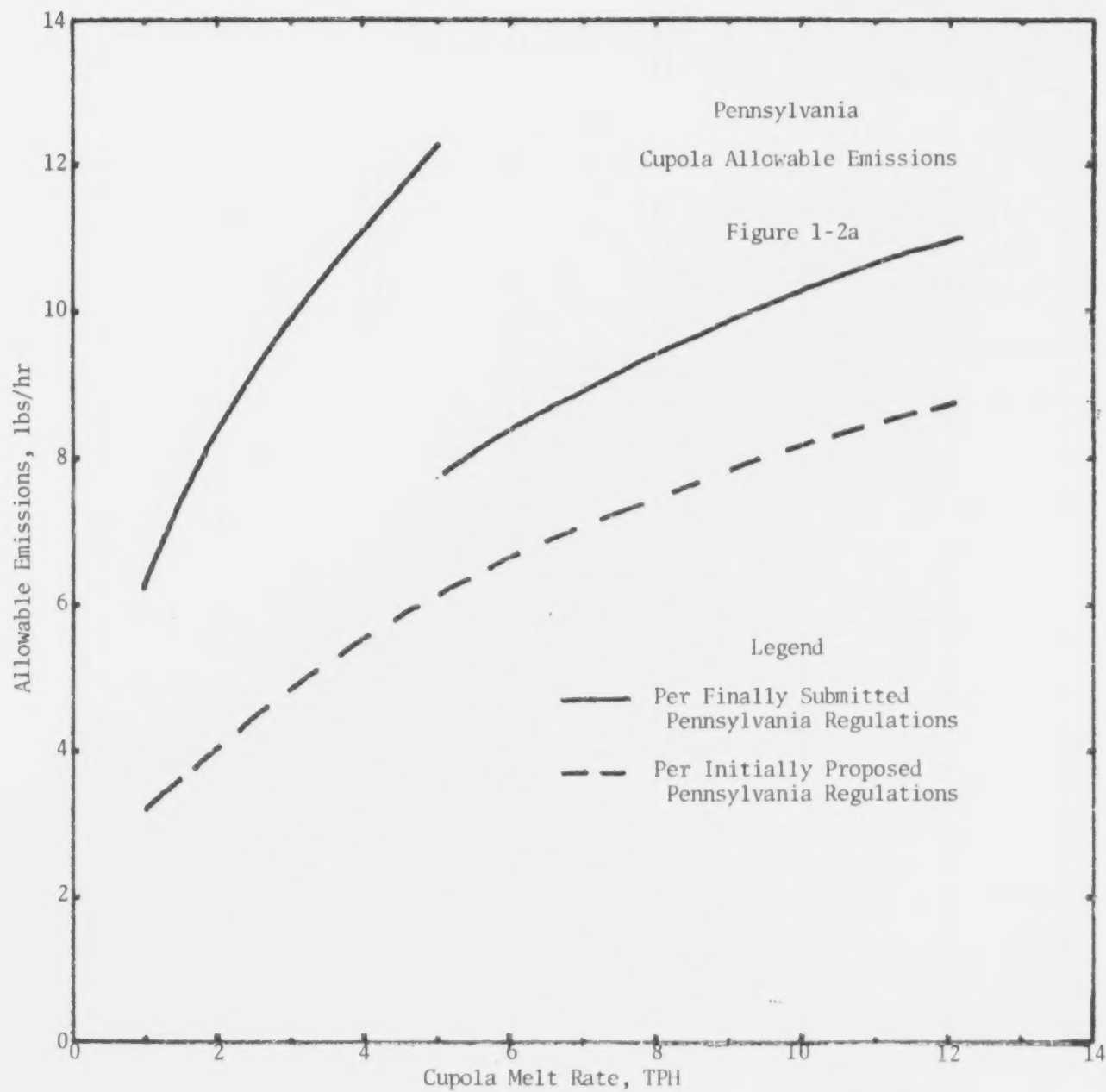
Table 4-Ca
PARTICLE SIZE DISTRIBUTION-CUPOLA EMISSIONS

Foundry	Cumulative Percent by Weight (Diameter in Microns)			
	-1	-2	-10	-20
9 ² *		30%	65%	82%
14 ²		64	98	99
18 ²			12	34
26 ²		13	45	55
32 ²			86	98
67 ²			15	15
67 ²				19
151 ²		0.6	3	8
A ⁵			5.5	7
B ⁵			13	32
C ⁵			12	17
118			25	38
218			26	36
318			28	23
418			30	32
A18	0	7	32	34
B18	0	7	41	47

* The number is a foundry designation code and the superscripts, the source reference for the data.

Table 5-Ba
PARTIAL LISTING OF INDUSTRY ASSOCIATIONS
RELATED TO FOUNDRIES

American Foundrymen's Society
Ductile Iron Society
Foundry Equipment Manufacturers' Association
Gray and Ductile Iron Foundry Society
Malleable Foundries Society
National Foundry Association



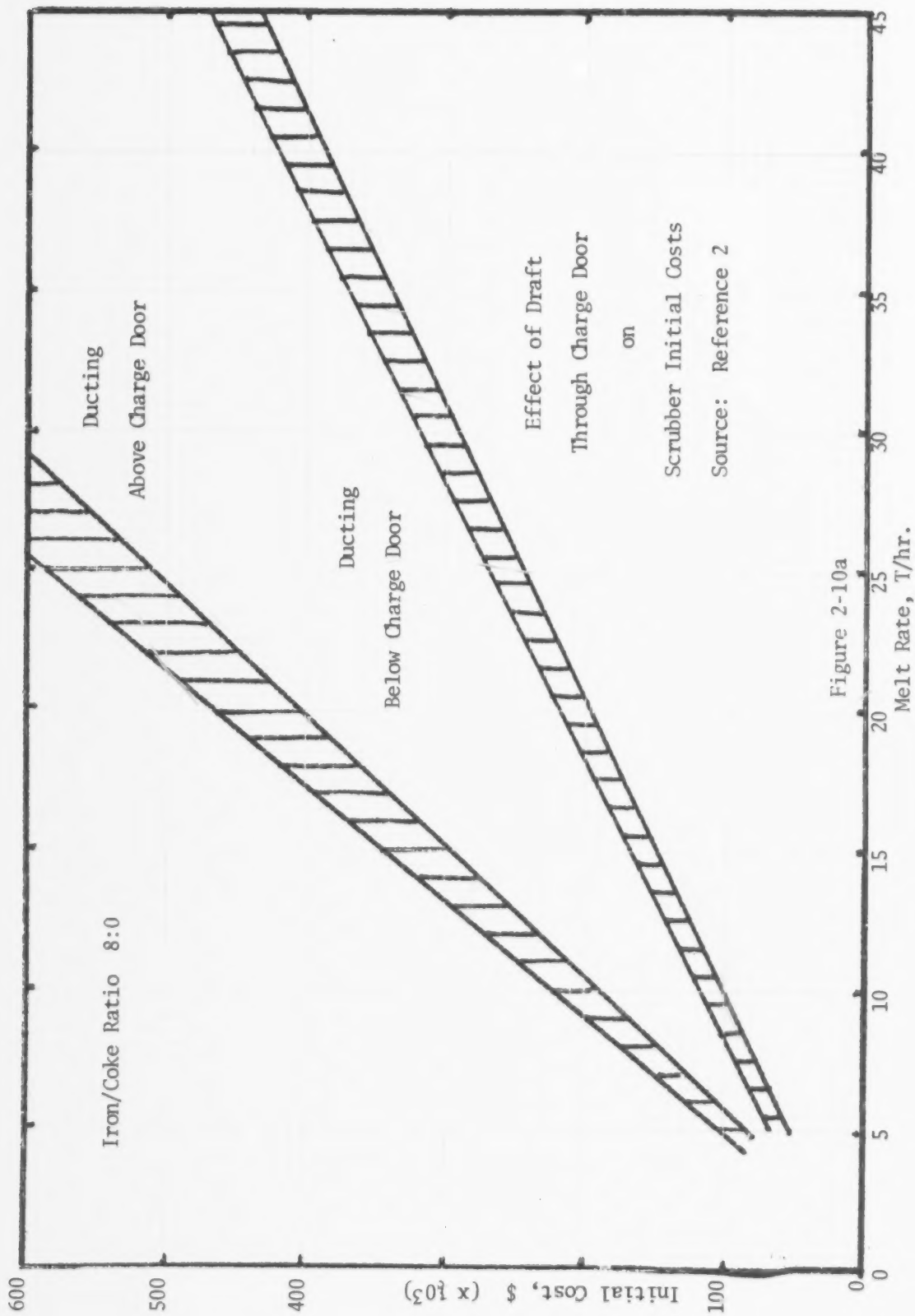
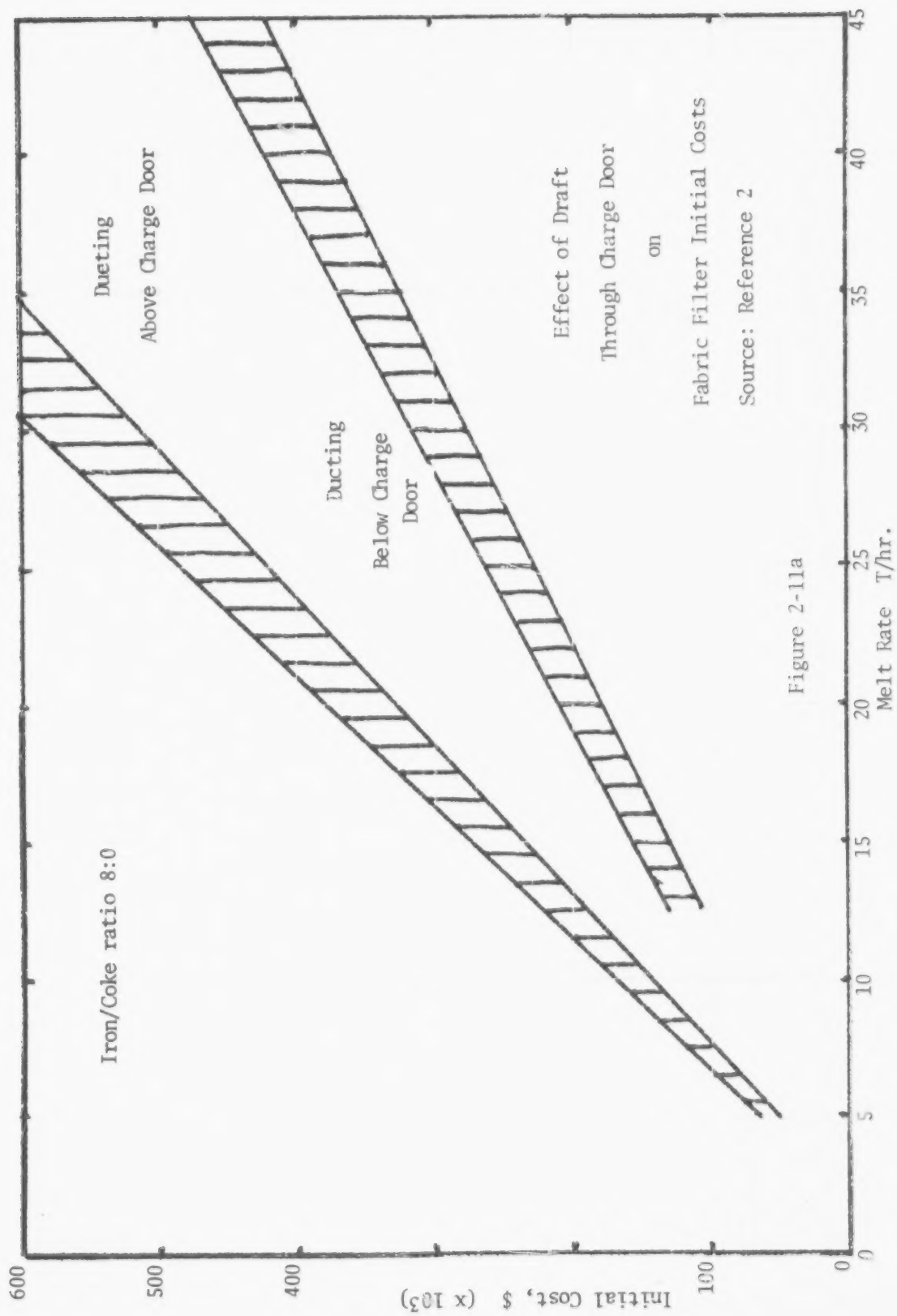
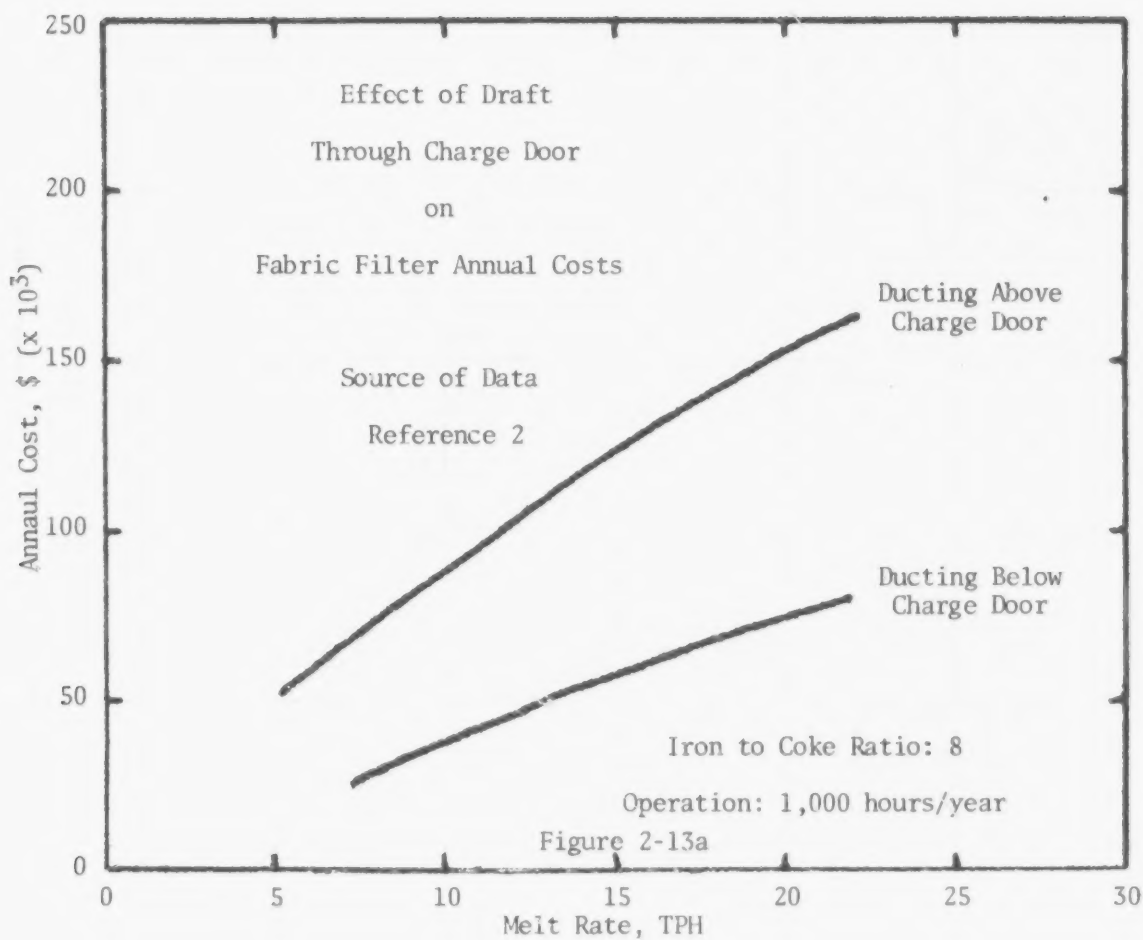
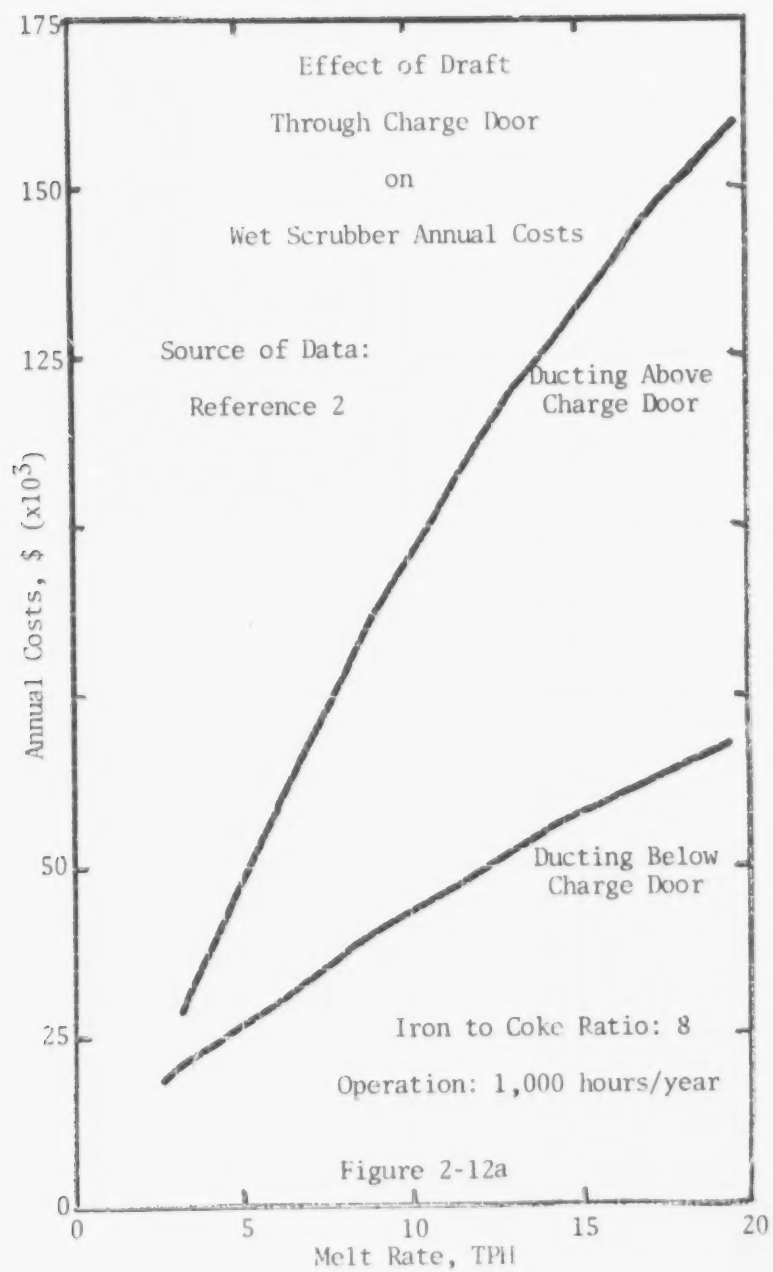
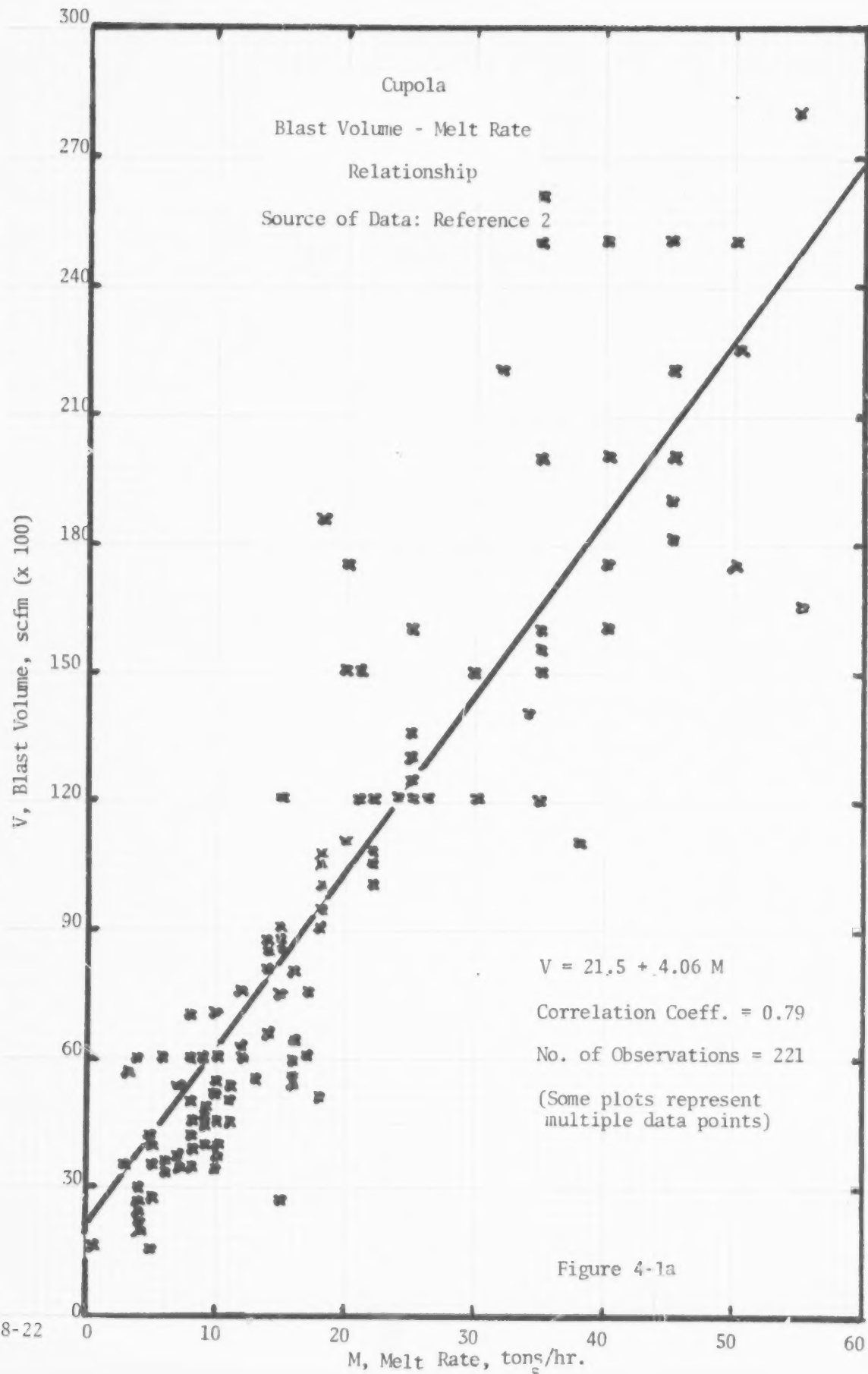


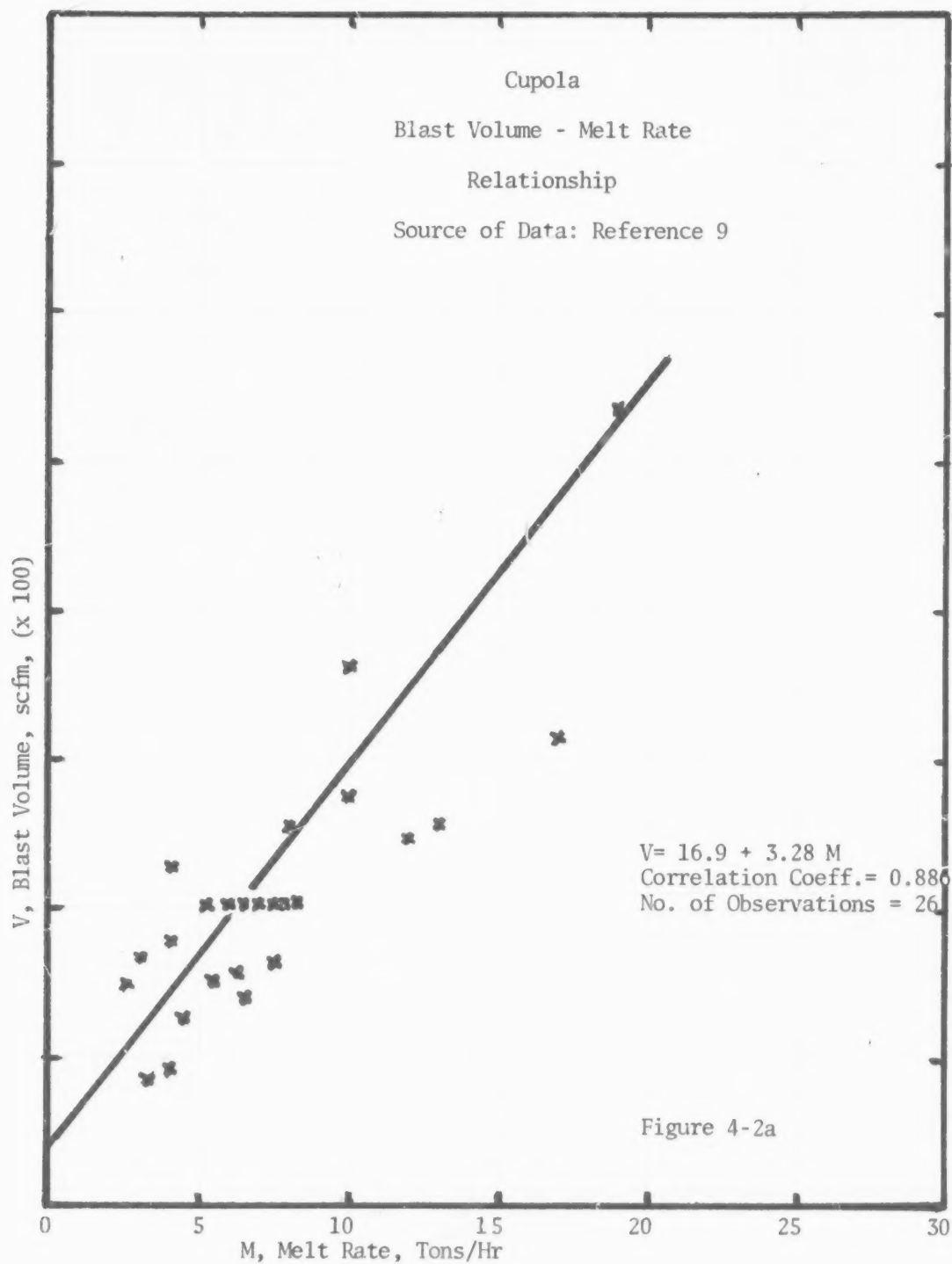
Figure 2-10a

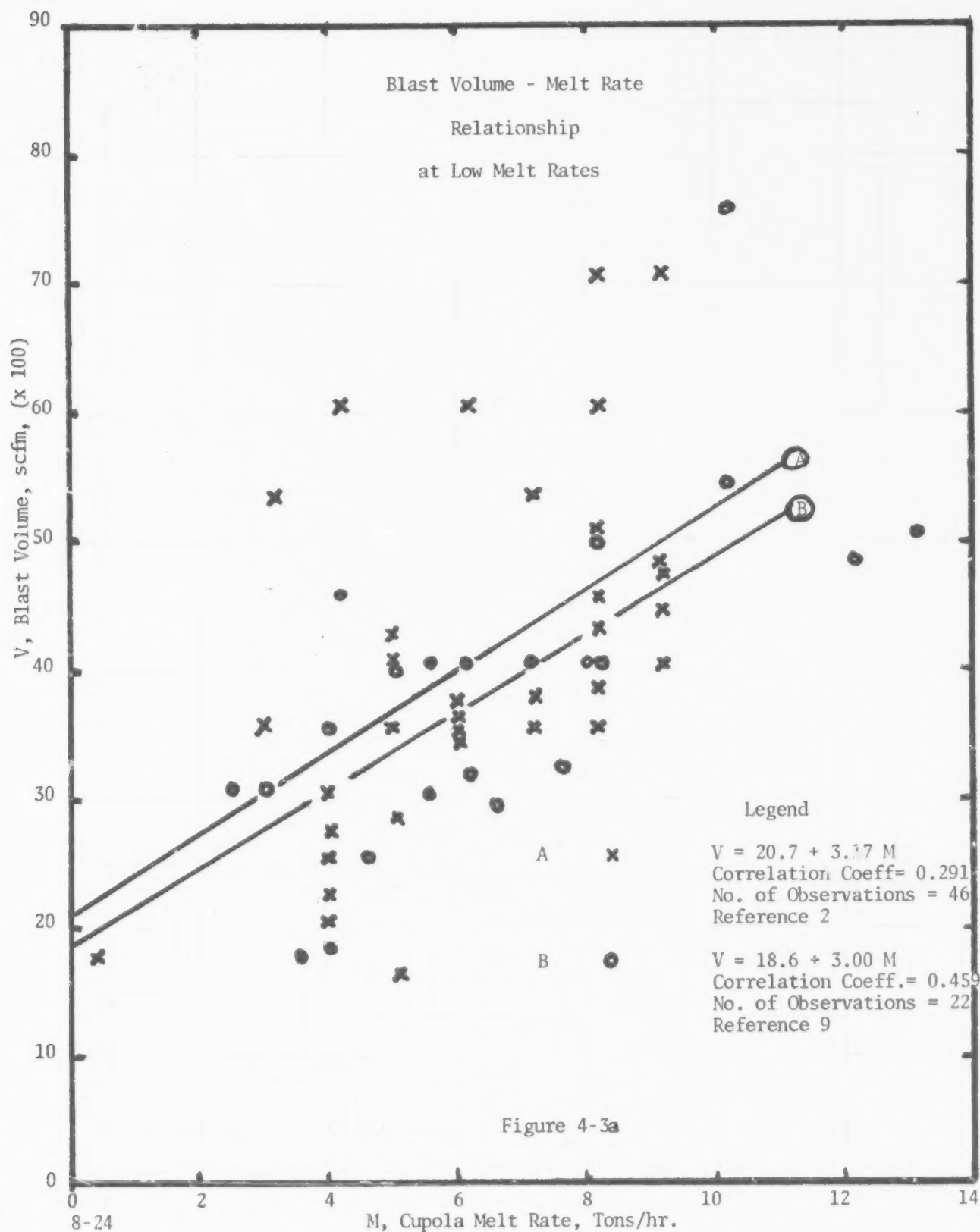












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